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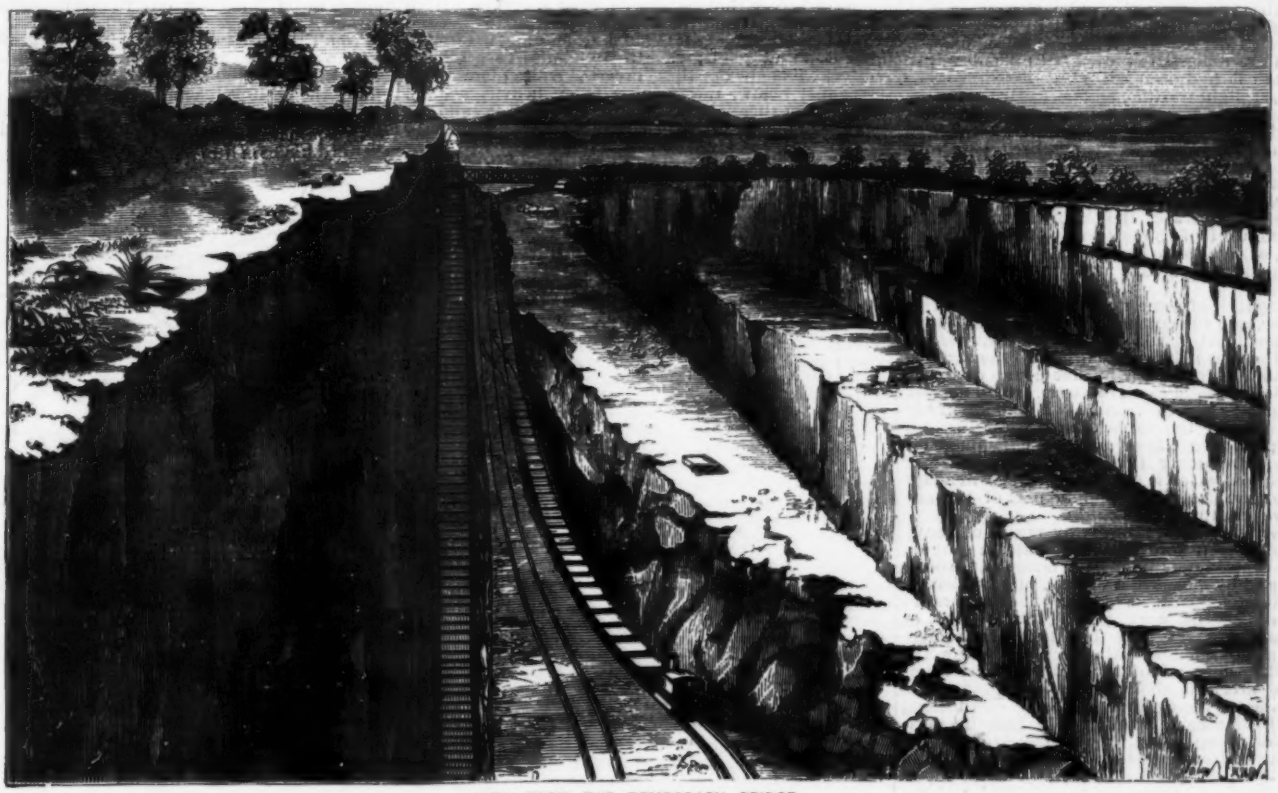
PROGRESS OF THE CORINTH CANAL.

THE entrance to the canal, which is to the north of Posidonia, is protected from the effects of westerly winds, which blow very hard in the gulf and soon get up a considerable sea, by a small harbor surrounded by heavy stone and concrete walls, and into which ships will come through a very narrow entrance, perhaps not more than from 80 ft. to 90 ft. across. The harbor itself, from the entrance to the commencement of the canal, is not more than 400 ft. to 500 ft., and its greatest width apparently does not exceed 700 ft.

It is in shape something like a quarter circle, the canal starting from what would be the center, or twelve of clock, and the entrance for ships being at what we might call half-past ten of the circle. Within the harbor there is a depth from five to eight fathoms. Immediately outside the sounding is 30 fathoms, and within a mile it reaches to a depth of 160 fathoms. Indeed, the little steam tugs have only to take the laden barges a very few yards outside the harbor to allow of the discharge of earth which has been taken from the lower or water level of the canal. As we enter the canal we see on the right or south bank, first a substantial, though small, stone house, for the accommodation of the foreman or entrance keeper of the canal, and a few yards further on an extensive workshop has been built, in which are departments for fitters, turners, blacksmiths, carpenters, etc., provided with necessary lathes, drilling machines, forges, hammers, etc., for the conduct of any repairs which may be necessary to barges, dredgers, wagons, permanent way, or engines.

A fine pair of shear legs has been erected in front of these workshops, fitted with all necessary winches and gear for the lifting of anything in use in the workings, and under which the great steam dredger Posidonia was placed, having her buckets changed or repaired



VIEW FROM THE TEMPORARY BRIDGE.

VIEW FROM THE RAILWAY BRIDGE.

THE ISTHMUS OF CORINTH SHIP CANAL.

on the day of which I write. On the northern side of the canal, and perhaps 100 yards above the workshop, a recess has been cut into the bank of sufficient dimensions to accommodate a little floating drydock, capable of taking on for cleaning, repairs, or otherwise, any of the smaller craft, including the tug boats and mud barges.

When I saw it, it was occupied by a floating crane of considerable size, which was undergoing a clean up and having a new coat of paint. Behind the little dock is a beautiful stretch of vineyard, and as waving cornfields abound between the canal and the ranges of grand hills on either side, those travelers who associate the name of canal with the dreary passage from Port Said to Suez will be agreeably disappointed when they first make the run from Posidonia to Isthmia. With the exception of the little floating dock, the northern side of the canal at this end will be without houses or work of any kind, so that all the space is available for depositing the earth and stones, in the form of a big plateau, which has been, or will be, taken from the workings above the water level.

No doubt this great plateau will be turned into use or ornament when the canal has been finished, for the earth is more or less rich. There is an absence of sand or stones, and vines or corn will flourish on it. Continuing our walk on the southern bank, we come, after the workshops, to a great store of patent fuel, which is used in all the tugs, dredgers, locomotives, and portable engines at work in the canal cutting, and about 100 yards further up a large, handsome stone house, fitted with verandas, balconies, gardens, and every modern improvement, has been erected for the director and officers of the western end of the canal.

For a distance of about half a mile above this house, or perhaps three-quarters of a mile altogether, the canal is finished and dredged to its full depth. Its sides are formed of very hard clay, so hard, indeed, that the men are obliged to face it with picks, and it looks as though it had been really cut through rock, with its hard, straight top line, and perfectly flat, even, sloping sides. The sides are parallel so far as the work is yet finished.

Up to this point the work has not been of a very heavy kind, as the level of the surrounding land is low, the water not being more than about 12 ft. to 14 ft. below the level, but from this point the land rapidly rises, and the great work of the Corinth Canal begins. At the present head of the waterway of the canal, so far as it goes, a large steam dredger is working, with a line of barges on either side, into which the earth is thrown.

The bed is formed of some peculiarly hard earth or very soft stone, and the cutting edges of the buckets of the dredger are fitted with a number of heavy sharp iron or steel teeth, which usually bring up the earth in small pieces, but very often a bucket comes up carrying a huge piece of solid earth or stone, which necessitates the stoppage of the machine, while in answer to the shrill whistle of the captain, men come forward armed with great long chisels and heavy hammers for the purpose of reducing this before mentioned big piece to such pieces of a smaller kind as will adapt themselves to the size of the tipping part of the machinery above and that of the chutes.

The dredger is moored securely by means of heavy chains and anchors ashore and round steam gear on board. The captain occupies a little house at the bows of the craft, and by means of a whistle, upon which he can blow different calls—a species of boatswain's whistle—he directs the work, pulling on the port or starboard chains, or stopping the whole of the huge machinery, as he pleases. At the place where the dredger works, the level of the ground in front has been brought down to about 5 ft. above that of the water by means of hand labor, the loose earth being thrown into little wagons running on De Cauville portable rails, which wagons are pushed along to the edge of the level and tilted, allowing the earth to drop in front of the dredger, by which it is again lifted, deposited in the barges, and taken out to sea. So far, therefore, we have two levels, that of the canal, in which the dredger is working, and the level 5 ft. above that, on which the first system of De Cauville wagons is working.

This second level extends at present about half a mile, and then rises to a third level, which is approximately 10 ft. to 12 ft. above it, or 15 ft. to 17 ft. above the water level, and this third level is now the position of the main work at the Corinthian end. This level, which we may call the third, runs for a distance at present of perhaps a little more than a mile; and as the country rises rapidly, its surface is in places 120 ft. below the level of the surrounding land, the sides being cut into the hard earth perfectly perpendicularly. At the northern side of this level the work is in progress, and being carried out vigorously, of reducing it to the second, or 5 ft. stage, a channel having been run along almost the entire length about 10 ft. broad by 10 ft. to 12 ft. deep.

In this channel two lines of De Cauville rails have been placed, upon which a large number of little tilting wagons are running. At the western end of this channel there is an inclined plane, up which the full wagons are hauled by a 12 horse power Hornsby portable engine, the empty wagons being allowed to run down at the same time. The loaded wagons are pushed along by men, and formed into a long line, which, when judged to be sufficiently long, is attached to a little ballast engine, drawn away to the plateau spoken of before, behind the floating dock on the northern side, and there discharged. Nothing could be better suited to this work than the De Cauville railways, for the lines are quickly laid, and the little wagons, though capable of carrying a very good load, are so light that should they upset they can be easily replaced on the line by one man.

It may perhaps be fair to remark here that the laborers employed over the whole of the canal works are magnificent specimens of Montenegrins, who come from the Black Mountains, and are known in Greece as Mavro Vrunies.

They are, generally speaking, peculiarly tall men, and of light though powerful physique; the average height of any hundred of them would not be less than 6 ft., and more probably 6 ft. 1 in. In physiognomy they are more like the Danes than any of the southern nations, and they are remarkable over all the Mediterranean for their personal beauty and great pluck. They are skillful navvies, and it is no uncommon sight to see one of them standing on a little projecting piece of earth 50 ft. or 80 ft. above the level, and with his crowbar or pick literally hacking the ground from under his feet. He is, however, always ready to leave the projection exactly at the right moment, and the next stroke after he has left it seems to send it crashing and tumbling down below.

Should the fall be soft or short, he will not trouble to move, but will work away until he goes—he never seems to fall—with the projection. No Greeks are employed in the works, as they are found to be too faint-hearted, besides lacking in muscular power, to render them of much service, and the main amount of labor is supplied by the Montenegrins, supplemented by some hundreds of Italians, who are also excellent navvies, and a large number of Austrians. The officers, directors, draughtsmen, and clerks are nearly, if not quite, all Frenchmen, the foremen and overlookers are generally Italians, and the men are as we have mentioned above—in all, probably about 4,000 men being employed in the work.

The floor of the level which I have called the third level is quite square and smooth, and carries three lines of heavy wooden wagons for the removal of the earth. These wagons run on a broad gauge, that is to say, a 4 ft. 8 in. gauge, and are drawn by powerful tank locomotives built by the Société des Ponts et Travaux en Fer, Paris. The earth from the sides at the upper end of this big cutting is thrown from above into the wagons, which, when full, are drawn away by their engines in long trains, and emptied into the great northern plateau at Posidonia.

At the head of the cutting a tunnel capable of carrying one line of rails is driven into the hill for the distance of about a mile. It is lined and supported by means of heavy timbers placed close together. High above the tunnel and from the top level of the ground a number of craters, looking like enormous funnels, have been dug or blasted with dynamite or other explosive. The apex of these inverted cones pierces into the tunnel below, the opening being heavily shored. The bases of these are in diameter about 80 ft., and the opening about 4 ft. square. All round the sides of these

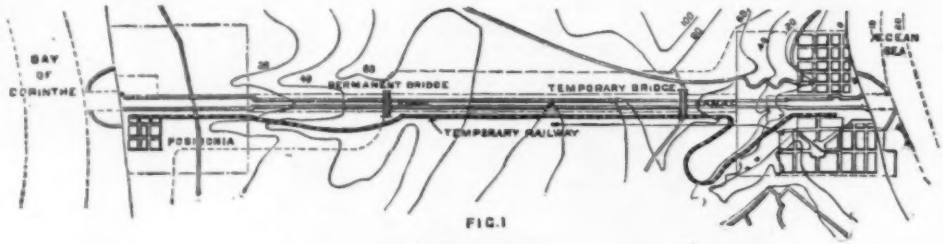


FIG. 1

PLAN OF CANAL.

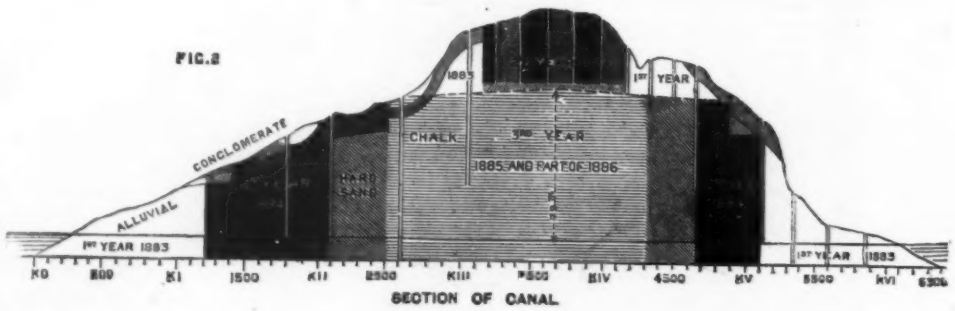


FIG. 2

SECTION OF CANAL

funnels, of which there are about eight or nine, the men are hard at work, picking, digging, and blasting, the wagons below being moved as rapidly as they are filled.

Half a dozen of the best men are employed round the discharging hole at the bottom of the funnel to keep it clear and always in working order, and it can readily be imagined the lively time they have of it, for not only have they to attend to their own business, but be ready ten times a minute to get out of the way of the avalanche of rocks and earth which comes tumbling down on the cry of "Garda!" from the men above. They, however, never seem to come to grief, and have learned by experience to judge to an inch where any great piece of rock or lump of earth will fall; and while working themselves industriously, they seem to have eyes all around, and to know almost by instinct where to look for danger from. Of course when the blasting charges are all ready to be fired, the men are called up from the funnel, as they seem to draw the line of danger only there.

A few yards to the east, along the canal, and from the last of the craters, and about one and one-half to two miles from Posidonia, a splendid piece of work is to be seen in the iron road and railway bridge which will carry the railway line across the canal on its way from Corinth to Athens, as well as the highroad between these places. The present railway line crosses the canal works over a little old-fashioned bridge, beside the new one on the west side. The old bridge was merely put up as a temporary makeshift, the best site, of course, being left for the new one, and the line at that part was laid down to lead to the new bridge, being only for the moment deflected so as to cross the old makeshift bridge.

At present the main carriage road between Corinth and Kalamaki, and so on to Magera, Eleusis, and Athens, crosses the canal workings at a great height, a little more than a mile to the east of the new bridge, passing over a wooden bridge erected for the convenience of the moment; but as the road runs beside the canal, it can be carried over the new bridge, as arranged, with ease.

Beyond the railway bridge, not more than 300 yards, the land reaches its highest point, and the cutting at either side is, or will be, a perpendicular precipice upward of 300 ft. deep to the level of the canal, and extending for a distance of about a mile and a half. At present the greatest work of the canal is being carried out in this cutting, where some 3,000 to 4,000 men are employed digging, cutting, blasting, and shoveling earth, sand, clay, and rocks from three levels or steps at each side.

Two lines of rails run along the bottom of the cutting, and upon these an ever-changing series of trains of wagons are ready to receive and steam away with the hundreds of tons of earth, etc., coming down every day. The top step, on the day under notice, stood about 75 ft. above the rails, and from it the laborers were throwing the earth over the heads of the men working on the lower steps into the wagons, and it would be very difficult to convey any idea of the noise, the dust, the shouting, the shrill shrieking of the engines, and the blinding, sweltering heat of the whole scene. A small army of boys is engaged supplying water to the thirsty laborers from wooden barrels, which are carried on the head, and which very quickly warm up under the almost tropical heat.

The men, especially the great Montenegrins, seem to work with untiring industry, clothed in a thick flannel of marvelous architecture, and with only a cap of the smallest dimensions, if they at all indulge in the luxury of head gear. The work in this Pandemonium of a cutting is directed by a number of gangers, or charge men, who carry their wishes to the men immediately under their orders by means of peculiar whistle calls, after the style of a man-of-war's boatswain. This cutting may be said to be bounded on the west by the new railway bridge, and on the east by a ramshackle temporary wooden bridge, which at present serves to carry the highway traffic between Corinth and Kalamaki across the workings. A sketch which I took from this bridge, looking toward Corinth, gives a very fair idea of the cutting, with the railway bridge in the distance; but I have left out the picturesque crowd of workers.

From the temporary road bridge the ground rapidly falls to the sea, and after a few minutes' very hard down-hill work, the new town of Isthmia at the eastern end of the canal is reached. This town is situated at the apex of a small bay in the Gulf of Athens, or Acquia, and is about a mile round the beach from the town of Kalamaki. When the canal has become a *fait accompli*, Isthmia and Posidonia will rise to importance as Kalamaki and Corinth decline.

A breakwater has been constructed across the entrance to the canal at this end, which will protect it from the effects of an easterly wind and sea, and will allow of vessels entering at any time without consideration for wind or weather. Behind the breakwater which joins the northern shore, a V-shaped bay, faced at either side with heavy stone walls, leads to the canal, and as this bay is of considerable area, several steamers waiting to enter the canal could be anchored within it in safety. On the southern side of the bay a beautiful residence has been built for the general director of the canal; and as this house is provided with very extensive well planted gardens for fruit and flowers, having extensive conservatories and verandas, as well as a private pier into the waters of the gulf for bathing, boating, or, as it is fitted with a little summer house, for dinners, the appointment of general director, at least in so far as his quarters are concerned, is not one lightly to be refused. Abutting the grounds of the director's house, a large stone building has been constructed for the offices and for the accommodation of the officers, and just below this is a floating dock for boats, dredgers, cranes, etc. On the other side of the harbor, and at the entrance to the canal, there is a large workshop, containing departments for turners, blacksmiths, carpenters, fitters, etc., in front of which the steam dredger Isthmia lay, receiving some necessary repairs. On the southern hills, and within various distances of the canal, a large number of pretty villas—some of which might claim to be called handsome houses—have been built, and are at present occupied by the engineers engaged in the works or by gentlemen who admire the natural beauties of the place and appreciate the fresh breezes from the hills and the almost perfect bathing which is here to be had.

The earth taken from the upper workings of the canal at the Isthmian end is deposited on an already huge embankment on the northern side of the town, and certainly robs that part of the country of any claims it might have advanced to beauty or picturesqueness. As at the Corinth end, the waterway of the canal has been here completed for a distance of about half a mile, and is to a certain extent a repetition of the work already described at Posidonia. Owing, however, to the more rapid rising of the land at the

eastern end, the tunneling begins much sooner than was necessary at the western end. That the canal will be a great work of engineering when finished there can be no doubt; but that it can ever pay as a commercial investment is a question of quite a different character. No doubt it will be used to a very large extent by vessels to or from the Adriatic, but their numbers are few and far between; while vessels from the Black Sea or Constantinople for Mediterranean ports, or *en route* for Gibraltar, will beyond question prefer to pass round Capes Malia and Matapan to incurring the delay and the expense of a passage through this canal. The projectors have gone into this question fully, it may be supposed, and have assured themselves that the venture will pay; but to a mind unsupplied with official data as to probable tonnage, however much local knowledge may be possessed, the scheme seems doomed to failure as a money-making enterprise.—*The Engineer.*

SIBLEY COLLEGE LECTURES.—1886-87.

BY THE CORNELL UNIVERSITY NON-RESIDENT LECTURERS IN MECHANICAL ENGINEERING.

I. THE TENDENCIES OF MODERN ENGINEERING.

By ECKLEY B. COXE, of Drifton, Pa.

GENTLEMEN OF THE CORNELL UNIVERSITY ASSOCIATION OF ENGINEERS AND ARCHITECTS: When I consented to appear before you as a non-resident lecturer, the question which naturally suggested itself to my mind was, What was the proper function of a person proposing to fill such a position?

Twenty or thirty years ago, when I was a student, the term was not employed, at least in this country. In most colleges the professors were few in number and did all the work of lecturing and teaching. The field covered by each professor was often greater than that occupied by three or four, in analogous institutions, at the present time. There was much more theory, and less practice, taught. The greater portion of the public knew little, and cared less, about technical education. In fact, with many people, the possession of a theoretical education in engineering was considered rather a drawback to a young aspirant for a position. To-day, fortunately for you and fortunately for the United States, public opinion has changed very much and very wisely in reference to this subject. Our country is now blessed with many institutions where all branches of science are taught, both theoretically and practically, many of them endowed by men who, although they had little chance of obtaining such an education themselves, thoroughly appreciated the importance of it to the young men who were growing up around them.

The idea of inviting gentlemen who are engaged in the active pursuit of their professions, and each of whom is practically familiar with one or more of the problems that an engineer is obliged to meet and solve, to appear before and address the students, who are actually engaged in acquiring their theoretical professional training, is a comparatively new one, and one which, to me at least, seems to promise much for the advancement of technical education in this country.

The function of the faculty in an institution of this kind is to put up, as it were, a skeleton structure, covering all branches of the science of engineering, giving to the student a thorough scientific and mathematical training, with broad general ideas of his subject, so that, when he has graduated, he will be able to work in the details of the particular part of the structure which he will be called upon to occupy during his life. It would be impossible for the professor, even if he were an expert in all the branches of engineering, to enter into every detail of all the departments of the profession, and, even if he had the ability and time, he would only waste them both in endeavoring to instruct the students in the lecture room in those things which can be acquired only by practical experience in the field, workshop, or mine. The most and best he can do is to give him a thorough scholastic and theoretical training, with some practical instruction in a few branches of the profession. For example: The professor of civil engineering can take his students into the field and lay out sections of theoretical railroads and canals; or he can take him into the machine shop, and teach him some of the more important details of the work done there, and which he may be called upon to supervise and carry out; or he can take him into the mine and teach him how timbering, or pumping, or cutting coal is really done. Now, as you will discover hereafter, such instruction is of the highest value, but that broad, thorough, practical training in each one's specialty which is necessary to make an expert in any profession can only be acquired by actual contact, day by day, with the details of professional work. It is not possible for institutions of this character to give such thorough and complete theoretical and practical training that when the students have graduated, they may be experienced engineers.

There has been much misconception, and, in some cases, much misrepresentation, in regard to the meaning of the diploma of a civil, or a mechanical, or a mining engineer. Young men sometimes enter a technical college with the idea that it is a royal road to learning, and that, by spending a few years in an institution of this kind, they will be capable of competing with those who have not only spent four years in obtaining their theoretical training, but perhaps a quarter of a century in the actual work of their profession. When a lawyer has been admitted to the bar, years elapse before he is fitted to try important cases in court; when a doctor has received a diploma, he trys to serve for several years as an assistant in a hospital. The best definition of the true meaning of a diploma that I ever heard was that given by my friend Prof. Albin Weisbach, son of the great professor of engineering. Some two years ago, talking over this subject with him, I asked him what he considered the true meaning of a diploma to be. He replied: "When we sign a student's diploma as mining engineer, we do not mean that he is really a mining engineer, in the broadest sense of the word, but merely that he has pursued with intelligence and profit, and has passed a satisfactory examination in, those branches of pure and applied science which the experience of those best fitted to decide has shown to be essential to any one who intends to become a thoroughly educated mining engineer." While pursuing his studies, the student naturally acquires some little practical experience; but the greater part must be obtained in the workshop, in the mine, in the field, or at the furnace. Leaving college thoroughly well grounded in the true principles of science, and familiar with the theoretical parts of his profession, he is in the best possible condition to learn with the greatest rapidity, and the least loss of force, what is necessary to complete his education.

It is the duty of each professor in an institution of this character to keep himself abreast with the advance of science and technology in his own branch, and to be constantly on the alert to obtain the earliest and most accurate information as to what improvements are being made, not only in this country, but also in Europe, and to continually improve and enlarge his course of lectures; so that the student, upon completing his course at college, will have a good general idea of the present status of the branches of his profession included in the course which he has been pursuing. It is not possible for one man to cover them all or to be even moderately familiar with several in all their details. Science has become so broad and deep that, had Humboldt been born at the present day, he could not, even with his great mind, peculiarly fitted as it was for the study of general science, have occupied the position he actually did in his own time. He would of necessity have been forced to become more of a specialist.

It seems to me that the plan of calling in the non-resident lecturer is a wise one. He cannot of course, in the time which is at his command, communicate to the students all, or even a very small part, of the practical knowledge of his profession which he is supposed to possess. To attempt to do so would be to waste their time. What, then, should be his aim?

After much reflection, it seemed to me that if each lecturer would endeavor to impress upon the attention of his hearers some one thought which to him seemed of vital importance, illustrating it with examples or facts taken from his practical experience, much good might be accomplished. With this end in view, I shall ask your attention to the consideration of the tendency of modern engineering, at least in one direction, and endeavor to explain it by a few examples drawn from the preparation of anthracite coal, a subject to which I have devoted a large portion of my professional life. If I should take a text for my address, it would be expressed in some such words as these: "Despise not the day of little things."

Engineering is a profession so broad and deep that men may spend their lives in it without ever coming in contact, or ever knowing of each other's work. Its tendency is toward specialties and detail work. While I would not of course be understood to say that great generalizations, such as the law of the conservation of energy, and great discoveries and inventions, such as the steamboat, the railroad, and the telegraph, will not occasionally be made, yet such revolutionizing inventions are likely to become more and more rare in proportion to the number of persons engaged in the pursuit of science and the mechanic arts. The great progress of which we see such convincing proofs everywhere around us is not due, except in a very small degree, to the great inventors and discoverers whose names are in every one's mouth, but to the thousands of patient, conscientious, untiring, self-sacrificing, scientific workers who, in all parts of the world, are devoting their best energies to the careful investigation of details apparently so trifling, of subjects seemingly so devoid of interest, that until recently most of the world looked on, and wondered if they are really sane to work so hard to accomplish so little. Now, however, the men of business, those whose capital is invested in the great industries of the country, are beginning to realize the importance of such work and the value of the men who are now doing it. Where one chemical analysis was thought sufficient a few years ago, hundreds are now made with much greater care and accuracy. No one thought or cared, then, whether iron or its ore contained a few hundredths of one per cent., more or less, of phosphorus. Now the presence of this small quantity is a bar to their use for many purposes.

On some of our great railroads no piece of iron is allowed to be used for the boilers of the locomotives until a test of its physical properties has been made. The lubricating and other oils used are no longer bought by guess, but accurate scientific tests and analyses are made, by which the article furnished is accepted or rejected. Hundreds, nay thousands, of such tests are made weekly, which but a short time ago would have been considered useless.

This great attention to detail work, and the amount which is being done, acting with other causes, is accelerating the division of engineering into a large number of branches. I can almost remember when, outside of the army, there was but one kind of engineer, and that was simply an engineer. He was supposed to cover the whole field. Now, in addition to the military, we have the civil, mining, mechanical, marine, and electrical engineers, and many of these branches are subdivided; the mining engineer may be a coal mining engineer, a metal mining engineer, or a metallurgist; a civil engineer may be either a bridge engineer, a sanitary engineer, or a railroad engineer, etc.

It seems to me that there is nothing that gives us such a vivid idea of progress in civilization as this necessity for the continuous subdivision of engineering and the infinite variety of the detail work now being done. Therefore, my young friends, those of you who are soon about to begin the battle of life and, with us older men, take your place in the ranks of the engineers of our country, I say to you, look calmly upon the prospect before you, but do not consider your profession as an easy one, promising great prizes and little work. If such are your hopes, you will undoubtedly be disappointed. The engineer of the future must be willing to devote his life to a continuous struggle, not expecting to win great victories, but only to aid in gaining very small ones. The aggregate of that done by us all, however, when combined, will do more than all that has yet been accomplished by the united efforts of the entire engineering world for the advancement of the human race. I wish to impress this upon you, knowing, as I do, how I felt when I began life as a mining engineer. It seemed to me that there were great things to be accomplished and great work to be done; but I found, as I advanced, that while great work *is* being done and great results accomplished—achievements such as the world has never seen—it is not due to the genius of the few, but to the patient and unremitting study and detail work of the hundreds and thousands engaged in our profession. Many a man whose name we do not know, whose life has been passed in some secluded spot, has contributed his mite to the advancement of our profession, and has gone down to his grave with no other reward for his unceasing devotion to the cause of science than the proud consciousness that, in some respects at least, he he has left the world better than he found it.

Engineering is a grand profession. There are, it is true, but few prizes in it. You may or may not be so fortunate as to obtain one; but *you can always do your duty.* No matter how humble the position that you may be called upon to fill, no matter how uninteresting your work may seem to be, by carefully studying those phenomena with which you are placed in contact in your professional labors, by noting, observing, and experimenting when you have a chance, and by publishing what you have found of value, in the proceedings of the technical societies or in the technical journals, you place the whole profession under obligation to you, and prevent waste or loss of valuable information.

There are men whose minds are peculiarly fitted to assimilate and combine the work which has been done by the thousands of careful observers and experimenters, who are gathering the facts and the data which are absolutely necessary to the former in order to accomplish anything of value.

As an illustration of the idea that I have tried to convey to you, I will now ask your attention to the subject of the preparation of anthracite coal, as carried on in Pennsylvania, with the results of which you are all probably more or less familiar. Anthracite coal, as you probably know, occurs in beds or veins, interstratified with sandstones, conglomerates, shales, and slates. The veins which are now worked vary from three to fifty feet in thickness. Some of the veins are very pure or clean, that is to say, they contain very little slate or other impurities mixed with the coal. Others have bands of slate or impure coal (known as bony coal) interstratified with the pure coal. The loaded cars as they come from the mine contain coal of all sizes, from lumps weighing several hundred pounds to the finest dust. Mixed with coal there is a quantity of slate, bony coal, rock, and iron pyrites, which come either from the roof or floor of the vein, or from the impurities interstratified with the coal. In this shape anthracite is not merchantable. With bituminous coal the case is different; in many of the mines where the latter is worked, it is divided into three sizes only, viz., fine, nut, and lump; and some mines make no separation, shipping the coal just as it is loaded inside; it is then called *run of mine.* This can be done with bituminous coal, as it burns much more easily than anthracite, the bitumen contained in it rendering it much more inflammable, and causing the fine particles to cohere, when the coal becomes heated, forming a spongy mass of carbon, which, when properly prepared, and all gas driven out, is technically known as coke. The result of this peculiar (coking) characteristic of bituminous coal is that the small pieces do not fill up the interstices between the large pieces, and thus choke the draught. The spongy mass of coke, being filled with innumerable small passages, allows the air to come in contact with the red or white hot carbon over a very great surface. With anthracite the case is different. Its action in the fire is precisely like that of a piece of stone or brick, except that the carbon, which is on the outside of the piece, and is exposed to the air, is oxidized or burnt, the rest of the coal becoming red or white hot, but not burning; the heat may or may not cause it to split or fracture, just as any piece of stone or brick might under the same circumstances; but there is no agglomeration, each piece, as it burns, diminishing in size, but never uniting with another. This peculiar difference in the way in which it burned prevented the use of anthracite coal for a long time as a fuel. In fact, this, perhaps the most valuable of all fuels, was for many years used only by blacksmiths in their forges, with a forced blast. The presence of slate and foreign matters in the coal, separating the particles or pieces of coal from each other, filling up the stove or grate in which it was burned, often rendered combustion very difficult, and sometimes impossible. In the early days, those using the coal often did not understand the difference between coal and slate.*

When anthracite was first mined and sent to market, the large lumps were picked out by hand and all the small coal and slate was left in the mines or on the dirt bank. There was no screening or mechanical preparation of any kind. The customers purchasing the coal broke it up by hand, and of course were obliged to throw away all the coal that was too fine to burn in the grates, which were the only kind of stoves then used. I hold in my hand a little pamphlet recommending the use of anthracite to the citizens of New York, published in 1825. It resembles very much the pamphlets now so common in this country in which people are now recommended to use patent medicines. It contains the usual certificates from respectable citizens as to its value, and also directions as to how it should be taken.

The next advance in preparing the coal was the introduction of bars or cast iron plates for the purpose of screening the smaller pieces, which had been previously thrown out on the slate bank, but which were sufficiently large to be used in the stoves then in use. There was possibly some attempt, when loading the coal in railroad cars, to throw out some of the pieces of slate found among these smaller pieces of coal. As can be well understood, in the course of time people found it much more convenient and economical to buy the prepared coal, which was already broken to the proper size, than to purchase the larger lumps and break them up themselves, as this required considerable labor and caused considerable loss in fine coal. The demand for this smaller size grew gradually, until it finally became necessary to increase the quantity of it above that naturally made in the mine, so as to supply the demand. This was done by having men, with hammers, to break some of the large lumps through square holes in cast iron plates on a platform.

The coal thus broken had the smaller sizes taken out

* My father told me that when he was a law student, which was about the year 1812, an effort was made to use anthracite coal in the office in which he studied. Sometimes they would have a splendid fire and the coal was very satisfactory, and at other times, for what was to them some mysterious reason, the coal would not burn at all. Of course the explanation was that when they tried to burn the coal mixed with a good deal of slate (which they thought was coal), they did not succeed.

by means of bars or plates, the small being thrown out on the dirt bank. For a number of years, all coal below what is now known as "egg coal" was considered of small value. In fact, all sizes below stove were thrown away, and stove coal, which is now the most valuable of the prepared sizes, sold for the lowest price. The next advance was the introduction of the revolving screen, with wire or cast iron segments to separate the small coal into different sizes and to take out the dirt. The breaking up of the coal by hand became very expensive on account of the immense amount of labor involved and the great amount of small coal made. This led to the invention of the cracker breaker or rolls, which have been used for over thirty years, to the exclusion of all other methods of breaking, except in a few special cases. They were first known as coal crackers or breakers, but they are now generally called rolls. They consist essentially of two cast iron cylinders of the same diameter, having protuberances or teeth on their periphery, so arranged as to either have a tooth in one of the rolls opposite a space in the other, or a tooth in one opposite a tooth in the other. There was a great deal of litigation in regard to some of the patents for the details of this apparatus. For many years, the only method of removing the slate and other impurities was to pick them out by hand after the coal had been sized and in some cases washed, so as to render the difference between the coal and slate as striking as possible; but of late years a number of mechanical devices have been employed with success as aids in obtaining the desired result.

Having thus briefly sketched the development of what is now an important industry, giving work as it does to probably from fifteen to twenty thousand men and boys, viz., the preparation for market of anthracite coal, I shall endeavor to give you, as briefly as possible, a general idea of the mode of preparation as at present carried out in one of our more modern breakers. With almost all coals except anthracite, the object of the operator is to obtain the greatest quantity of the larger coal and the least of the smaller. In most cases the miner is paid much more for the larger coal, and sometimes they are not paid at all for the small; the object to induce the miner to use every effort to produce as great a quantity of large coal as possible. With anthracite coal, for several reasons, the case is different. In the first place, for domestic purposes, which is by far the most important use, large coal is not wanted, and for many manufacturing purposes only the very small coal is bought. Lump and steamboat coal (the two largest sizes) are shipped principally to blast furnaces, rolling mills, foundries, steel works, and to railroads for locomotives; but for most of these establishments anthracite does not possess such advantages over bituminous coal and coke, which are in most places much cheaper, as to give rise to a large demand for large sizes. There is also a great difference in the quality of anthracite coal. In some districts the coal is so friable that no large sizes of coal are made, as they do not stand transportation well, and will not carry the burden in a blast furnace. Some varieties of anthracite contain a large amount of sulphur, phosphorus, or ash, which prevents their use for making iron, particularly where it is desired to make a very pure iron, though they may be well adapted to domestic use. Some coal clinkers very easily. Such coal is not adapted to use in locomotives, for burning under boilers, or for any work where a great heat is required. If ever you have anything to do with the coal business, you will hear a great deal about coal clinkering. The fact is, that any coal can be made to clinker, provided it is burnt in such a way as to produce a temperature sufficient to fuse its ash. Some coals do not clinker because their ash fuses at a very high temperature. Others do not clinker because so impure that they cannot generate heat enough to fuse the ash. It is possible to take two coals, neither of which will clinker if burned in an ordinary way, and by mixing them to produce clinkering coal; that is to say, the addition of the one coal increases the temperature at which the mixture burns, and at the same time increases the fusibility of the combined ash. These and other peculiarities of anthracite render the preparation much less simple than with other coals.

When a new mine is opened, before deciding upon the plan for the breaker, that is, the building in which the coal is to be prepared, it is necessary to determine the character of the coal, the uses to which it can be applied, the amount of impurities found in the vein, the question as to whether its impurities, such as slate and bone, separate easily from the coal that is split off, or whether they adhere to it, whether the coal in the different veins or beds is of such a character that the most valuable product can be made by preparing them separately or together.

Here is a table exhibiting the stock sizes as usually sent to market:

SIZES OF COAL.

	Through.	Over.
Lump		Bars 4 in. to 6 in. apart.
Steamboat	Bars 4 in. to 6 in. apart.	Bars 3½ in. apart.
Broken	Bars 3½ in. apart.	2¼ in. to 3 in. square.
Egg	2¼ in. to 3 in. square.	1⅞ in. to 2¼ in. square.
Stove	1⅞ in. to 2¼ in. square.	1 in. to 1 7-16 in. square.
Chestnut	1 in. to 1 7-16 in. square.	¾ in. square.
Pea	¾ in. square.	⅝ in. to ⅞ in. square.
Buckwheat	⅝ in. to ⅞ in. square.	Slit strong ¼ in. wide.
No. 2 Buckwheat	Slit strong ¼ in. wide.	Slit scant ⅛ in. wide.
Culm	What is left.	

The car coming from the mine contains a mixture of all sizes of coal, slate, and other impurities, with more or less mud, due to the water which is generally found in the mines. The miner is supposed not to load any slate that is too large to be handled with a shovel. The small pieces are difficult to separate with only the light of a miner's lamp, and must generally be taken out in the breaker. The car goes to the dump, where it is emptied into a chute.

There are two kinds of operations necessary to prepare coal, viz., those performed by hand and those by machinery. The first consist of:

Sizing by hand.
Slating by hand.

The second of:

First, sizing by machinery.
Second, crushing by machinery.
Third, slating by machinery.

The machines used for sizing are:

Fixed bars.
Movable bars.
Revolving screens.
Shaking screens.

Those used for crushing are:

Rolls with movable teeth (steel).
Rolls with fixed teeth (cast iron).
Rolls fluted.
Crusher (like Blake crusher).

Those used for slating are:

Machines depending on the difference of specific gravity of coal and slate—jigs.
Machines depending on difference of form of coal and slate.
Revolving screen slate pickers.
Machines depending on the difference of the angle of friction of coal and slate.

[The lecturer here occupied the principal portion of the time remaining in technical descriptions of machinery and processes, illustrated by elaborate general and working drawings, which it would be impracticable to reproduce, except in a separate article.]

Having given you, thus briefly, a general idea of the mining and preparation of anthracite coal, you will naturally ask, What has this to do with the tendency of modern engineering? My answer is this:

That the results obtained by these complicated structures called coal breakers, with their complicated machinery, the better ones costing from fifty to one hundred thousand dollars, can be obtained by a single man with a properly constructed hammer. If you place before him a few hundred pounds of coal in a pile, he would first begin by selecting from the pile the lumps of coal and slate, placing the pieces of approximately the same size together; and if he should come upon a piece composed partly of coal and partly of slate, he would break the piece up, placing the pieces of coal thus obtained with the coal previously selected, and throwing out the slate, until all the coal and slate larger than culm or dust had thus been separated. While it would take a great deal of time and cost a good deal of money, he could, if sufficiently careful, make an absolute separation into pure coal and pure slate, the coal being all properly sized, with the exception of the dust, which latter could be thrown away, as is now done in the breakers. This was precisely what *was* done in the infancy of the coal trade, with this exception, that most of the smaller coal, known as egg, stove, chestnut, pea, and buckwheat, was not utilized, only the larger pieces being sent to market. The most complicated, the most expensive, and the most perfect breaker can do nothing more. In fact, it is very doubtful whether we can prepare the coal by machinery as well as it can be done by hand; but the difference in expense would be very great, and the cost of preparation by the first method would be more than the price for which the coal could be sold.

The modern breaker is not the invention of any one man or any dozen men. It has been brought to its present state of perfection by the intelligence, perseverance, observation, and experiments of thousands of men, who for the last half century, in all parts of the anthracite coal region of Pennsylvania, have been devoting their thoughts to the solution of the problem how to prepare anthracite coal in the best manner and with the least cost, how to improve the machinery and avoid waste. It is now impossible to say to whom we are indebted for many of the most important improvements. What to us who are now conducting these operations seems a matter of course was only learned by long continued, patient investigation. Those familiar with coal breakers will understand what I mean when I say that in every breaker there is hardly a piece of machinery that has not been invented or improved by some one whose name is now most probably forgotten. If you compare the plan of the breaker built half a century ago, consisting simply of a set of chutes and bars to separate the coal into different sizes, with the plan of a modern one, with all its improved machinery, it is hard, even for an expert, to realize what an amount of brain work has been necessary to produce the result at which we have arrived to-day. Coal is mined, prepared, and sent to market which, but a few years ago, would have been valueless on account of the difficulty and cost of its preparation. Those who enter into this business, as those who enter into any other branch of engineering, will find that it is the small things, the details, apparently of the most trifling importance, which cause success or failure in business through life. Benjamin Franklin said, "Take care of the pennies, and the pounds will take care of themselves;" and I, paraphrasing this, would say to you, "Take care of the details of your professional work, and the great things will take care of themselves."

THE CONSTRUCTION AND MAINTENANCE OF MACADAMIZED ROADS.*

THE construction and maintenance of macadamized roads are subjects which do not require the application of that amount of scientific knowledge necessary in some other branches of a town surveyor's work; nevertheless, much care and no little skill is required in satisfactorily constructing macadamized roads; and equally much, if not more, is required in their maintenance.

The subject will be more or less interesting to members, as the proportional area of their towns are macadamized. In many towns nearly the whole of the streets are paved in some form or other, while in others, of which West Hartlepool is one, nearly the whole of the streets are constructed of this material. When J. L. Macadam introduced has improved system of road repair, he became, about 1816, very popular, and for a time was much sought after by county and other boards. Glowing accounts were given by him of the amount of expense which could be saved by the adoption of his system. In his opinion there was no necessity to lay the foundation of a road on any ground, even the most soft and peaty, with large stones. It was a great waste of time, materials, and money.

The only thing to make a good foundation was to lay down a bed of from eight to ten inches of finely broken stone and to keep the ruts raked in until the stone united by its own angles. Macadam also asserted that the principle of road making which he thought most valuable was to put broken stone which should unite by its own angles upon a road, so as to form a solid, hard surface. There must be no admixture of binding material, but the stone must be perfectly clean. This rule of Macadam's, which in theory might appear all right, but which in practice is found absolutely impossible to accomplish, is much cherished by amateur road makers, who ascribe all the ills that unpaved roads are heir to, to the non-adoption of this rule. When roads have become dirty, owing to the traffic grinding down the material, they assert that had the material been allowed to unite by its own angles, instead of adding binding material when the road was repaired, a perfectly clean road would have been the result. In fact, a beautiful moasic pavement would adorn all our streets, which, in the language of Mr. Macadam, would be perfectly unaffected by the weather. No wonder then that the general ratepayer, who has no knowledge of the subject, should get somewhat mixed, and be ready to exclaim, "The whole concern is improperly managed." But the picture is delusive. In the first place, it would be simply impossible to construct a satisfactory road for the use of ordinary traffic over boggy or peaty ground without the aid of some material other than 10 in. in depth of finely broken stone. In many cases the whole of the material would be pushed out of sight in a few days, and where this did not take place, the stone would be so intermixed with soil that the ideal road formed of perfectly clean stones "united by their own angles," could not possibly be obtained. In the second place, when the surface of a road is repaired by adding new material, one of three things must take place, no matter how the material is consolidated: either a sufficient quantity of binding material must be added in the first instance, the material itself must be detrited by rolling or by the traffic until the interstices are filled, or the consolidation of the material must continue until from the old surface a sufficient quantity of pulverized material has been forced up by displacement in the operation of consolidation.

It would seem more reasonable to add the necessary binding material in the first instance than to provide it at the cost of the excessive deteriorating of the broken stone, both from a point of cleanliness and economy—economy, because the material used for binding only costs about 1s. per load, whereas the broken stone will cost from 8s. to 9s.; cleanliness, because by adding the "binding" the broken stone is not so much pulverized, and in consequence wears much longer and cleaner.

Mr. G. F. Deacon, late city engineer of Liverpool, had doubtless been troubled with some of the followers of Macadam when he allowed himself to be induced to try the experiment of consolidating broken road stone without the aid of "binding." He has stated that under a 15-ton steam roller, preceded by a water-cart, 1,200 yards of trap-rock macadam, without binding, could only be moderately consolidated by twenty-seven hours' continuous rolling; if bonded with hard rock chippings from a stone breaker, the same area might be moderately consolidated by the same roller in eighteen hours; if bonded with silicious gravel from ¾ in. to the size of a pin's head, mixed with about one-fourth part of macadam sweepings, the area might be thoroughly consolidated in nine hours. He further stated that macadam laid according to the last method wears better than that laid by the second, and that laid by the second much better than that laid by the first.

Doubtless much credit is due to Macadam for the indomitable perseverance shown in bringing about an improvement in the method then adopted of repairing roads. The system advocated then, however, would not be tolerated now; nor would many engineers risk their reputation by trying to carry out rules so impracticable. About the same time Macadam was so busy, Telford was equally busy constructing roads in Scotland, but on an entirely different system. Telford believed that one of the most important things in connection with the construction of a road was to obtain, wherever possible, a perfectly hard, dry, and non-elastic foundation. His general practice was, if the line of road was found at all soft or wet, to thoroughly drain the site, after which a bed of rough stones from 6 in. 8 in. deep was laid by hand compactly together and the interstices filled in with small pieces, and upon this was spread a layer of stone broken so that the largest piece would pass through a ring 2½ in. in diameter, 6 in. in depth, and covered with 1 in. of fine gravel for binding purposes. Macadam tried to show that by adopting a non-elastic foundation, as suggested by Telford, the broken stone used for top covering would be considerably damaged by the wheels passing over it; while in his system of constructing roads without foundations, the roads would yield with the pressure, and so save the stone from being crushed. This argument appears all right in theory, but in practice it is found not to hold good, it having been abundantly proved that one of the most essential elements in the economical maintenance of a road, either paved or macadamized, is to have a perfectly hard and non-elastic foundation. Sir John Macniel states that where there is a yielding and elasticity in the road, there must be motion among the particles with which the road is formed, and this motion produces wear.

It is said by Mr. H. R. Reynolds, who wrote an article on the wastefulness and inefficiency of road repairs, which appeared in the *National Review* for September, 1885, that "as a rule the surface of the roads of the British Isles are far inferior now to what they were in the coaching days." That where there used to be a hard, smooth, convex surface, free equally from ruts and holes, from dust and mud, and needing but very slight repairs, there is now, generally, to be found a road full of holes and puddles, ruts and ridges, covered with deep mud in wet weather or with dust and loose material during a dry season. I deny that as a rule our roads are in a worse condition now than in the coaching days. Some of the main lines formerly used by the coaches are somewhat worse than they were when the coaches ran; but as a rule the principal lines of traffic are in a much better condition than what they were then, and the roads constructed since that time have been constructed and are maintained in a far superior manner. In nearly all cases the writers of the coaching days condemned the roads, and some of them in language more forcible than polite. The method principally adopted in the construction of streets and roads at the present time is to excavate or fill in the ground to the required levels longitudinally and transversely, taking care to provide for the foundation being properly drained, either by rubble or other suitable drains. To thoroughly consolidate the ground by ram-

* By J. W. Brown, C.E., F.G.S., West Hartlepool. A paper read before the Association of Municipal and Sanitary Engineers and Surveyors, at West Hartlepool, on Oct. 2.—*Building News.*

ming, upon which a bed of slag or rubble broken to a 3 in. ring is spread to such depth that when thoroughly consolidated either by the steam or horse roller it shall measure not less than 8 in., and upon this is spread whinstone, broken to a 2½ in. ring, to such a depth that when thoroughly consolidated by the steam roller it shall measure not less than 4 in. in depth. The depth of both slag and whinstone of course varies in the various towns and countries. In the North the foundation of the roads is often formed after Telford's method, by pitching the bottom with slag or other suitable material with pieces from 6 in. to 8 in. in depth, packed closely together by hand, and the interstices filled in with small pieces. Although the latter system is advocated by some, it is generally admitted, at any rate for town roads, that it is better to use material broken as before described. In each case the top layer is finished in the same manner. Concrete undoubtedly makes the best foundation either for paved or macadam roads; but its cost precludes its use for macadam, although it is usually adopted for the foundation of pavements. Some diversity of opinion exists as to the correct method of repairing roads, some holding that before applying any new material to the surface of a road, no matter how much worn, the whole surface should be checkered or loosened, so as to enable the new material to incorporate with the old; they also holding that by the entire surface being loosened, the act of consolidation by the roller does not injure the stone so much as when the road is not checkered, the loose material forming a kind of cushion for the new. Moreover, a less quantity of binding material suffices when the road has been loosened, as when the new material is being consolidated the old is displaced, and so forced up into the interstices of the new layer. Others hold that it is a waste of labor to checker the whole surface, more particularly when the road has become considerably worn and weak; the old coating, being well watered, is deemed to be sufficient to soften the surface so as to admit of the new material being incorporated with the old without material injury. The former of the two systems appears to me to be the most reasonable, and has been practiced by me for many years. The stone principally used in the North for repairing macadam road is a basaltic rock obtained from Great Ayton, Cockfield, and other places along the North of England dikes. A similar stone to this, both in composition and specific gravity, is found at Rowley Regis, and is locally known as "Rowley Rag;" it is largely used in Birmingham and the neighboring towns. In Leicestershire and Nottinghamshire the road stone is largely supplied from the Leicestershire syenitic granite quarries. This syenitic granite is considered by many to be a superior stone for road construction to the true granite. In many Yorkshire and Lancashire towns limestone is used; it cannot, however, in any way be considered equal either to the granite or basalt for road work; its power of resistance to a crushing force is much less, and it is very sensitive to atmospheric changes. Much controversy has taken place with respect to the most suitable size to which road stone should be broken. Mr. Ellice-Clark, in his paper read before the Cyclists' Society, on the maintenance of suburban and rural roadways, recommended that granite should be broken to an approximation of from 3½ oz. to ½ oz. per stone, flints 5 oz. to ¾ oz., limestone 6 oz. to 1 oz. It is much more convenient in practice to train the men to gauge the stones by the ring than to weigh them. If the stone be broken to such a size that the largest piece will not weigh more than 3½ oz., a very large proportion will be found utterly useless to withstand the pressure of the ordinary traffic, and with heavy traffic will speedily be reduced to mud. If it be necessary to break granite small, so as to reduce the interspaces, why should it not be equally necessary to break limestone small for the same purpose?

A very important part is played by the binding material used in the construction and maintenance of macadam roads, and unfortunately for us in the North, a suitable material is difficult of access. Selected road scrapings in some cases answer well; but in others the scrapings are most unsuitable. However, in the neighborhood of the Hartlepools no other material can be obtained except at very high prices, and the roads suffer accordingly. The material most suitable for this purpose is a fine pit gravel of a rather loamy nature, but as free as possible from lime. The best substitute known to the author in this district, for the ordinary binding material, is pitch and tar, used with the broken stone as tar macadam. This mixture has been largely used in Leicester and other towns, and has the virtue, when properly prepared, of being of such an elastic nature as not to be materially affected by the vibration of the traffic. It holds the several pieces of stone of which the road is formed firmly in position, and so reduces the wear to a minimum; moreover, it is non-absorbent, and prevents the water percolating into the foundation. Although a trial of this has been recommended by the author, it does not appear to find much favor as yet.

PETROLEUM CARRYING STEAMERS.

ON THE CARRIAGE OF PETROLEUM IN BULK ON OVER-SEA VOYAGES.*

By Mr. B. MARTELL.

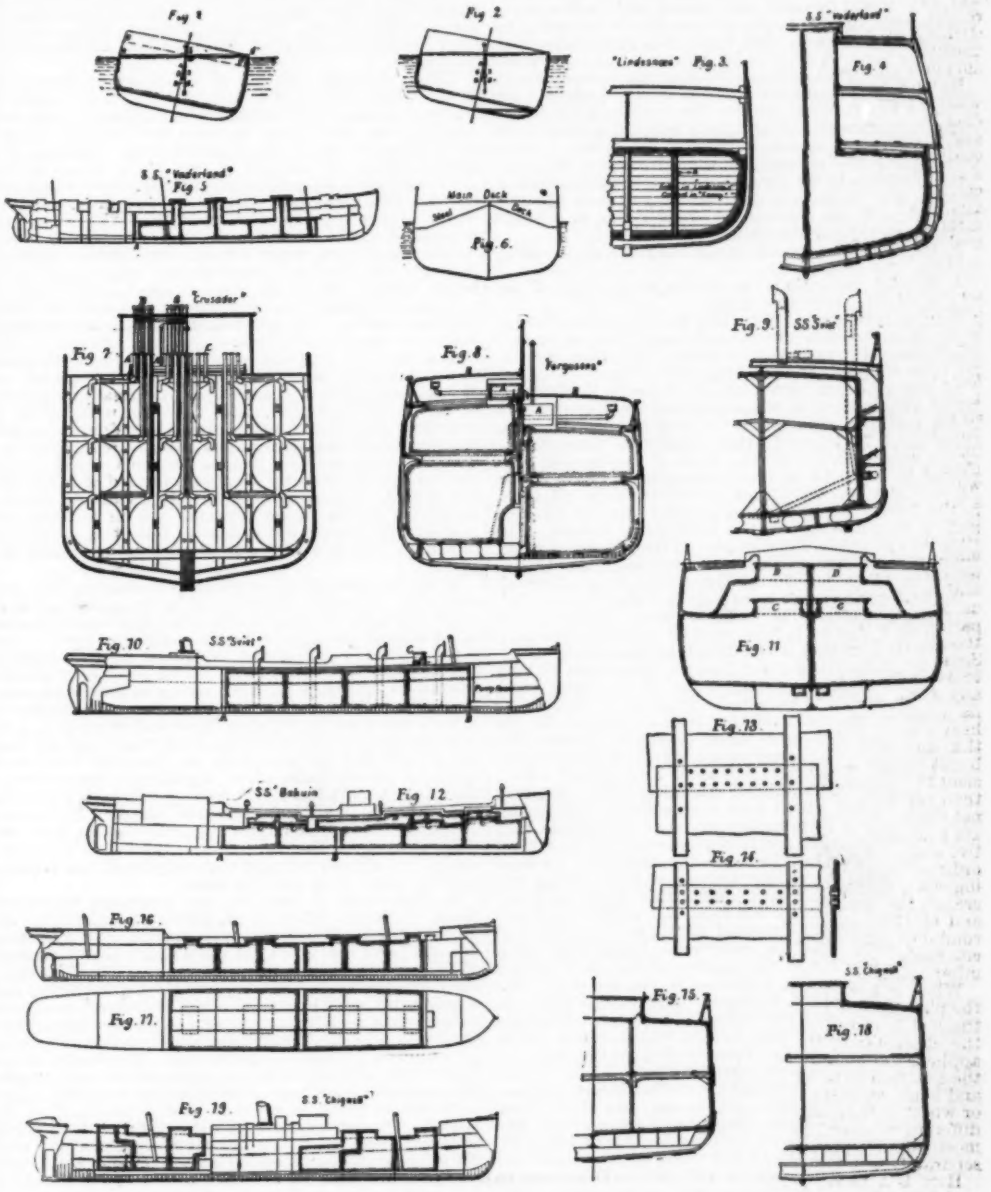
NOTWITHSTANDING the fact that thirty years have now elapsed since the discovery of petroleum in America, and that its production has grown so rapidly as to cause it to occupy the fourth place on the list of exports from that country, the efforts of British ship owners have been up to the present time but little exercised in competing with foreign ship owners for the over-sea carrying trade of that commodity. The reasons for this indifference may, perhaps, not be difficult to trace. It could not have been in consequence of the limited extent of the trade, as we find that this has been constantly increasing, and that no less than 1,531,000 tons were exported from the United States alone, representing in the aggregate a freight value of over a million and a half sterling, while of this amount about 227,000 tons were brought to the United Kingdom. The real cause is probably to be found in the nature of the cargo itself; in the danger arising from its inflammable properties; and from the difficulty of eradicating the smell of the oil, which thus renders a vessel unfit for the carriage of general cargoes after its discharge. The latter consideration has led to the carriage of petroleum—particularly as regards wooden vessels, which are more permanently affected—becoming almost a distinct branch of trade. Further, while the general cargo-carrying trade of the world was fairly remunerative, the same necessity did not exist—in view of the great proportion of tonnage held by British ship owners—for engaging in a trade to which the objections alluded to attached. The consequence has been that foreign owners of wooden sailing vessels have practically possessed a monopoly of over-sea petroleum carrying.

The consideration to which I wish first to direct your attention is as to the economic aspect of the question of the carriage of petroleum on board ship for over-sea voyages. Nearly the whole of the petroleum shipped in America for British and European ports is carried at present either in barrels or in tin boxes cased with wood. An ordinary barrel is 33 in. long and 25 in. in diameter at the middle, and weighs when full about 400 lb. Such a cask holds about 42 imperial gallons, and its own weight is 64 lb., or about one-fifth of that of the oil it contains. It is estimated that in stowing this cargo three and a half casks take up on the average a ton of 50 cubic feet, and it would therefore occupy 80 cubic feet per ton dead weight. But as most modern three-deck steamers, fitted with water ballast in the holds, in the usual way, cannot be brought to their load draught with cargoes occupying more than about 50 cubic feet to the ton, it will be seen that a great loss of cargo-carrying power is sustained by shipping petroleum in such vessels in casks, through the fact that the whole of the available cargo space is occupied long before the vessel is brought down to her proper load draught.

Thus, by way of illustration, if a steam vessel that could carry 2,000 tons of cargo, occupying as a limit 50 cubic feet to the ton, were filled with petroleum in barrels, she would carry only 1,240 tons dead weight. Of this quantity, moreover, about 16 per cent. would represent the tare of the casks, thus reducing the actual amount of petroleum to 1,050 tons. From this again it is usual to deduct 2 per cent. for leakage, and if such an amount of leakage does occur in practice the net weight of oil usefully carried becomes reduced to about 1,030 tons, as against 2,000 tons of ordinary dead weight cargo. As the specific gravity of American kerosene is 0·80, and that of Russian about 0·82, it would occupy in bulk less than 50 cubic feet to the ton, the average volume being about 25 cubic feet, and therefore no difficulty in carrying a full cargo would arise. The special fittings requisite for such a method, including the pumps, would of course have the effect of greatly reducing the above difference of 970 tons against the barrels, but there would be still left a large margin in favor of the carriage of oil in bulk.

But the advantage due to a difference in carrying power, great though it be, is not the only consideration. Another important economic question which arises in connection with the barrel system is that of the cost of the barrels themselves. Their value in the United States is stated to be from 4s. 6d. to 5s. 6d. each, and, with the exception of the few that are taken back to America, they are sold in London when empty for from 3s. 6d. to 4s. each. The depreciation of from 1s. to 1s. 6d. in the value of the barrel, which amounts to as much as from 350*l.* to 475*l.* for one voyage in the case quoted above, is saved under the bulk system. At present it has to be borne by the consumer of the oil, and by enhancing the cost has an effect in restricting the use of the commodity. This would disappear if the employment of casks were discontinued.

The loss is even greater in respect of the cases in which a large proportion of the oil is carried. The raw tin is bought in Wales, shipped to the United States, and there made into boxes protected by a wood casing. The cost of these cases is nearly equal to that of the oil they contain. On their arrival at the port of discharge they have, when emptied of their contents, no value whatever, and the full cost of their manufacture has to be charged upon the oil; at the same time some advantage is gained in carrying power, as the cases stow more closely than barrels.



THE TRANSPORTATION OF PETROLEUM IN BULK.

If petroleum is to be carried in bulk, certain points must be kept in mind:

1. Provision for the expansion of the oil under an increase of temperature. For an increase in temperature of 40 deg. Fah. the increase in volume would be about 2 per cent., and in some of the plans with which I am acquainted this degree of expansion has been allowed for.

2. Provision for keeping each tank full by automatically supplying any loss due to leakage or to contraction consequent upon a fall in the temperature of the oil.

To make the reason of this clear, let it be supposed that the vessel in Fig. 1, which contains oil with a free surface, O O_1, becomes inclined through a small angle, O S H. The wedge of oil, O S H, is transferred to the position, O_1 S H_1, and consequently the common center of gravity of hull and cargo moves away from its former position, G, in the middle line to a new position, G_1. The center of buoyancy also moves from B to B_1, in the ordinary way. We shall have, therefore, the resultant

* Abstract of paper read at the twenty-seventh session of the Institution of Naval Architects, at Liverpool.—*Engineering*.

upward pressure of the water, equal to the weight of the laden vessel, acting vertically through B_1, and an equal weight downward through G_1. The distance, A M, between the points in which the lines of action of the two forces cut the middle line of the vessel measures the righting moment at small angles of inclination in the same way as, under ordinary circumstances, G M does. I have, therefore, called it the effective metacentric height. If the extent of free surface be large enough to cause G_1 to pass beyond the vertical through B_1, the vessel will be unstable in the upright condition. If the vessel has a ballast tank beneath the oil cisterns in which leakage to any considerable extent can collect, an additional wedge of oil is transferred from one side to the other as the vessel inclines, as shown in Fig. 2, resulting in a further decrease in the effective metacentric height.

To illustrate the importance of this point I will suppose a "three-deck" vessel, 250 ft. long by 33 ft. broad, with a load displacement of 3,500 tons, to have a midship compartment 30 ft. long extending from side to side. If the level of the oil in such a compartment were slightly lowered, the effective metacentric height would be reduced by as much as 7 in.; and if the leakage were to collect in the bottom of the vessel over the same area, we should have, in the case of a flat-bottomed vessel, nearly double this decrease in metacentric height. It will be easily understood that such a loss of metacentric height might in practice be attended by serious consequences, and hence it is very desirable to minimize the area over which leakage at any one point would have effect, by subdividing the hold space, as well as by making good any loss due to leakage. By fitting a longitudinal middle line bulkhead the loss of effective metacentric height, by a fall in the level of the oil over the same area, is reduced to one-fourth, and by subdividing the oil-carrying space by numerous transverse bulkheads the extent of the free surface in connection with leakage in any one compartment becomes reduced, and the consequent danger due to a loss of initial stability correspondingly diminished.

3. Provision for the escape of the gases given off by the oil.

4. Special precautions to prevent the passage of any of the oil into the boiler space.

Having enumerated the chief considerations inseparable from the safe carrying of petroleum in bulk, I shall proceed to notice the several plans that have so far been adopted, or are being carried out.

In more modern times, the first vessel in which, so far as I am aware, it was attempted to dispense with casks, and to carry oil in bulk, was the wooden ship Charles, of 794 tons. In that vessel two rows of iron tanks, constructed to fit the form of the section, were placed in the hold, and two other rows in the 'tween decks. She carried fifty-nine such tanks in all, those in the 'tween decks holding about 12 tons of oil each, and those amidships in the hold about 30 tons. The Charles was successfully employed during three years, from 1869 to 1872, in the trade between the United States and Europe. In the latter year she was burned.

Several wood vessels were engaged about this time carrying petroleum in bulk between America and Havre and Antwerp, but most of them disappeared. Very little is known of the details of the arrangements made in those vessels, but I am in possession of very full information regarding some of the later ones, which are stated to have been fitted out in a manner superior to the bulk of the vessels engaged in the trade. Among these were three Norwegian vessels, Fig. 3, belonging to the same owner, adapted for this purpose in 1878. They were fitted all fore and aft with a 3½ in. middle line bulkhead extending to the height of the hold beams, which were close ceiled on the under side, the ceiling forming the crown of the tanks. The hold was further divided into compartments by several wood thwartship bulkheads to the height of the hold beams. Inside the ceiling proper of these vessels was laid a lining of felt, and within this again an inner wood ceiling. Midway between the middle line and each side, stanchions formed of 3½ in. planks bolted together were fitted to every hold beam, but for a length of a few feet at the upper end the middle plank was omitted to enable washboards, marked A on Diagram 3, to be reeved through. The washboards ran all fore and aft, and were intended to prevent the rapid rush of the oil from side to side, which would otherwise take place as the vessel rolled, in the event of the tanks becoming only partially filled. In the 'tween decks a number of iron tanks were fitted, but I understand that in the Lindesnes, the only one of the three still engaged in the trade, they have been removed, and the space occupied by oil in barrels. One of the three vessels disappeared after a few voyages, while another, the Nordkyn, grounded in the River Delaware in 1879, and discontinued thenceforth to carry oil in bulk.

Another vessel very similarly arranged was the wood bark Fanny, of 1,153 tons, which disappeared on her first voyage in 1880. She differed from those just described in having a coating of 2½ in. of cement, Fig. 3, laid upon the ceiling in lieu of felt, and within this, again, an inner ceiling 1½ in. thick. The Fanny carried oil in barrels in the 'tween decks.

The first steamer built specially for the carriage of oil in bulk was completed in 1872 by Messrs. Palmer & Co., limited, for a Philadelphia firm. She was named the Vaderland. The owners were offered a favorable contract by the Belgian Government, and, in consequence, she has never been engaged in the special trade for which she was designed.

Notwithstanding the non-employment of this vessel in the oil trade, a brief account of the arrangements for the carriage of oil in bulk in iron steamers thought suitable in 1872 will not be without interest at the present time. The machinery in the Vaderland was fitted aft, Figs. 4 and 5, and in the main hold throughout a length of about 162 feet, a longitudinal middle line bulkhead extended to the height of the hold or third tier of beams, below which the oil was to be carried. The main hold was further divided to the height of the hold beams by four transverse bulkheads into ten separate compartments. The hold beams, which were very deep, were plated both above and below, and each compartment communicated with the upper deck by means of an oil tight trunk hatch, extending to that deck, as shown on Diagram 4.

As it was not proposed in this vessel to permit the oil to extend to the outer skin, an inner skin was fitted as on Fig. 4, the space between the two skins being 26 in. at the middle line, diminishing to 20 in. at the upper turn of the bilge, and above to the height of the hold beams. The large trunk hatchways were intended to serve the purpose of feeders in the event of leakage, as well as to hold the excess of oil caused by expansion under increase of temperature. Although in this vessel the hold containing oil was separated from the boiler space by a thwartship coal bunker 8 feet long, so great was the desire to prevent even the possibility of accident through leakage, that three transverse bulkheads, marked A in Fig. 5, were fitted within a space of two feet.

The Vaderland was followed in 1873 and 1874 by the Nederland and Switzerland respectively, two vessels of about the same size as the former, and similarly constructed, with the exception that as favorable contracts were offered in other trades, as in the case of the Vaderland, the machinery was not placed aft.

No subsequent attempt has been made, so far as I am aware, until quite recently, to employ steam shipping for the purpose of transporting petroleum in bulk across the Atlantic. It was not on the Atlantic, but on the Caspian, that the problem was first brought to a successful issue. The scarcity of wood in the locality, and the consequent great cost of barrels compared with that of the oil they contained, led, or rather forced, the Messrs. Nobel, to whom the credit of the new departure is due, to turn their attention to the question of the carriage of petroleum in bulk. They accordingly had some vessels built for this purpose, and in 1879 they began to run from Baku to the mouth of the Volga.

These steamers, several of which are of large size, being 250 feet long and 28 feet broad, with a draught of water of 11 feet, now number about eighty in all, and they perform the voyage between the two ports named with marked success as regards both economy and safety. They are not all of one type. Some of the later ones carry the petroleum in cisterns, of which the bottom and sides are formed by the outer plating, while others are fitted with tanks which are independent of the structure of the vessel. Some of the former have two longitudinal bulkheads running through the forehold, and several transverse bulkheads further subdivide the oil space. The engines are placed amidships, and abaft these in the after hold are fitted two cylindrical vertical tanks, rising above the level of the deck.

As a result of six years' experience of the working of these steamers, many of which have been built at Motala in Sweden, it is found very necessary, whatever be the system adopted, that the workmanship be of first-class quality. All seams are at least double riveted, and no tightening material is used. In some of the smaller vessels built at Motala for the Caspian trade, the roof of the cisterns has been formed of steel plating sloped, as shown in Fig. 6. It is claimed for this method that the slope prevents the oil striking the roof of the cistern too violently, but it is somewhat difficult to see how such a result is obtained under the plan.

While the practice of carrying petroleum in bulk has met with so much success, and is regarded with so much favor on the Caspian, so great has been the mortality among the wooden vessels engaged that it has been gradually going out of favor in the Atlantic trade. Nearly the whole of the oil so shipped during the last twelve years has been either in barrels or cases. Recently, however, a further step toward carrying oil in bulk has been made, upon improved principles. Last year the large composite ship Andromeda, of 1,871 tons net, owned by a German firm, was specially fitted with tanks for the oil trade. Her registered dimensions are 270·6 feet by 37·1 feet by 25 feet, and she carries seventy-two tanks in all, two rows resting upon the ceiling in the hold, two rows upon the orlop beams, and two other rows upon the 'tween deck beams. The Andromeda has already successfully completed two voyages between New York and Germany.

In September of last year an American merchant, Mr. L. V. Sone, of New York, patented a plan for "improvements in vessels for transporting liquid cargoes in bulk," and has fitted up the wooden bark Crusader, of 643 tons, in accordance with the patent. The vessel has made three voyages between the United States and this country with safety, and has delivered her cargoes in first-class condition. A plan of the arrangements is shown in Fig. 7. They consist of three tiers of circular cylinders placed tier above tier. The vessel carries forty-seven of these cylinders, arranged in such lengths that an end of each is located beneath a hatch, and each one is fitted so as to be independent of all the others. To each cylinder is attached a pipe, A, which passes up into the hatch above, to be connected with the hose for filling or emptying the cylinder. A separate pressure pipe, B, attached to the top of the cylinder, passes also up through the hatch and extends to some height above the deck. Its purpose is to carry away any vapor that may be given off by the oil. Each of the pressure pipes is also connected by a branch with a pressure tank or reservoir, C, standing upon the deck. The purpose of this tank is to keep the liquid in the cylinders under constant pressure, and to supply any waste due to leakage. It also serves as an overflow tank into which the oil finds its way when an increase of volume occurs through an increase of temperature.

The first steam vessel adapted in this country for the carriage of oil in bulk was the Fergusons, of 1,551 tons gross, altered by Messrs. R. Craggs & Sons, of Middlesbrough, in the latter part of last year. Two rows of large iron tanks, Fig. 8, are fitted in the hold and two others in the 'tween decks. These tanks are specially shaped to fit the form of the vessel, and fill nearly the whole of the hold and 'tween deck space, a passage way of 2 feet being left at the middle line. They are filled by branch pipes from a 5 in. main carried along under the upper deck beams in the fore and after holds, and are emptied by the same system of pipes, each tank being capable of independent connection with the pumps. To keep the tanks quite full, and at the same time to provide for the expansion of the oil, a regulating tank is fitted in the 'tween decks, and connected with each of the system of tanks arranged in the hold. A second tank, A, placed in the hatchway on the upper deck, is similarly connected with the 'tween deck tanks. The separate regulating tanks are fitted in this instance to obviate the great pressure that would be brought upon the lower tier if they communicated with the tank on deck.

To take up any overflow from the regulating tanks, and also to furnish, if necessary, a reserve supply for filling those tanks in the event of leakage, an overflow cistern is fitted in the hold immediately beneath the regulating tanks. The tanks are ventilated by means of branch pipes, P, led into the main pipe, running all fore and aft, and connected with ventilators fitted on the deck. To guard against the ignition of vapor, the mouth of each ventilator is covered with a sheet of gauze, and the sluice valves usually fitted to cargo vessels have been removed from the bulkheads to the engine and boiler space, to prevent the escape of any leakage from the tanks into that compartment. The chief objection to this arrangement appears to be the difficulty of gaining access to the sides and bottom in way of the tanks, thereby precluding any examination of the interior of the vessel, or repairs being effected without considerable expense.

Another plan for improvements in the construction of "navigable vessels for carrying liquids in bulk, including cargoes of a volatile character, such as petroleum, turpentine, and the like," has been proposed by Mr. Swan, of the firm of Sir W. G. Armstrong, Mitchell & Co., limited. By Mr. Swan's method the hold is divided by a middle line longitudinal bulkhead, and further subdivided by a series of transverse bulkheads into compartments bounded at the top either by the vessel's deck or a specially fitted platform. As in some of the Caspian steamers, the oil extends to the skin of the vessel, and to each compartment are fitted one or more trunkways, either circular in section or of any other convenient form, partially filled to insure that the corresponding compartment is full, and also to provide for the contraction or expansion of the oil. A number of ways in which the trunkways may be fitted are suggested by Mr. Swan. One feature of the method is the arrangement for recording the height at which the liquid stands in the trunkway. For this purpose a piston is fitted to the trunkway and floats on the liquid, a graduated rod attached to it passing up through a stuffing-box in the cover. A small pipe in the cover in the trunkway admits of the escape of the vapor. As in other plans, by a suitable arrangement of pipes each compartment is capable of being separately filled or emptied. To provide for any leakage through the end bulkheads of the compartments, a well is formed on the fore side of the boiler space, and arrangements are provided to enable the liquid to be pumped back into the trunkways. Sir W. G. Armstrong, Mitchell & Co., limited, have under construction two vessels designed in conformity with this plan, and the efficiency of one of these vessels, which has been completed, will soon be tested. She is named the Gluckauf, her registered dimensions being 300·5 feet by 37·2 feet by 23 feet, and gross tonnage 2,297 tons.

Another steam vessel, the Sviet, Figs. 9 and 10, built for the Russian Steam Navigation Company last year, by the Motala Company, who have had great experience in the building of vessels intended to carry petroleum in bulk, has been specially designed to convey the oil from Batoum to European ports, and differs in her construction from those already described. Her engines are placed aft, and double bulkheads, marked A in Fig. 10, forming a "water bulkhead," are fitted on the fore side of the cross bunker. Forward of this, for a length of 140 feet, the vessel is divided by a middle longitudinal bulkhead, and by several transverse bulkheads extending to the upper deck. In each of the compartments so formed a cistern is constructed, the sides of which are built within the sides of the vessel, leaving a passage of about 3 feet. Similarly a space of about 20 inches is left between the upper deck and the top of the cistern. The plating of the top of the cellular bottom with which the vessel is fitted forms the bottom of the cisterns, which are further divided by a steel water-tight flat into an upper and a lower tier. There are sixteen such cisterns in all.

On the fore side of the foremost oil cisterns two bulkheads, about 2 feet apart, marked B in Fig. 10, are fitted, forming what the builders term a "gas protection," and before this are placed the powerful pumps for emptying the cisterns. Each cistern is provided with a trunk 3 feet by 2 feet 6 inches, extending to about 2 feet above the deck, and covered by a water-tight crown in which a manhole and an air and sounding pipe are fitted. For filling the cisterns the oil is conveyed in pipes from the wharf to the feeding cistern, C, Fig. 10, placed forward on the deck, and from this a pipe is led on each side into the pump room and connected each with a fore and aft pipe carried between the cisterns and the vessel's side. By means of branches from the fore and aft pipes the several cisterns are filled or discharged, the arrangements being such that each cistern can be filled or emptied independently. A spare cistern is provided in the pump room to supply any loss due to leakage. The pumps are able to discharge the whole of the cargo, about 1,700 tons, in five or six hours with proper facilities for discharge. A complete arrangement of pipes and ventilators is provided for ventilating the space around the oil cisterns. The sides of the cisterns are not connected with the sides of the vessel, the object being that they may remain intact in the event of concussion or damage to the latter. It is the practice, however, to drive soft wood wedges about 4 feet apart between the tank sides and the two plate stringers on each side, as shown on the section.

It is claimed by the builders of the Sviet that the following are among the advantages of the arrangements adopted in that vessel: the cisterns are at any time open to inspection, and in case of need to repair also, they are easy to fill or empty without being opened, while the system of ventilation has shown itself to be in every way practical and satisfactory. But, however complete may be the design and arrangement of the tanks in this vessel, the plan is one which, from its cost, has hitherto failed to commend itself to the ship owners of this country. For very little more than the sum which the Sviet cost to build, it would be possible to construct a steamer on other plans, similar to some described in this paper, capable of carrying nearly twice as much cargo. It should be added that the Sviet has, quite recently, brought a full cargo of kerosene to London from Fiume, when I had an opportunity of inspecting her before the discharge of the cargo, and found that it had been carried with little or no leakage on the voyage.

Another plan for the carriage of petroleum in bulk in steam vessels is that adopted by Messrs. William Gray & Co., of West Hartlepool, in a new iron vessel named the Bakuin, Figs. 11 and 12, now complet-

ing for a London firm. Her registered dimensions are 260 feet by 36 feet by 17·4 feet, and her gross tonnage 1,527 tons. The great bulk of the oil in this vessel is carried beneath the lower deck, a novel feature of which is that the beams are given a camber in the opposite way to that usual in ships. The object of this sagging of the beams at the middle is to enable the tanks to be completely filled and sufficiently ventilated. The air, while the tank is being filled, or the vapor given off at sea, collects naturally under the deck near the beam arms, from which it is led away by means of suitable ventilators. A longitudinal middle line bulkhead extending to the height of the middle deck divides the main hold, and transverse bulkheads further divide it into compartments of from 32 feet to 36 feet in length.

As shown in the sketch of midship section, the Bakuin has a cellular bottom, the crown of which forms the floor of the oil tanks. Above the cellular bottom to the height of the 'tween decks, the oil extends to the side, as in some other plans. In the 'tween decks, and of the shape shown on the section, are built a number of additional oil compartments. They do not extend either to the side of the vessel or to the deck above, and it is claimed for this plan that while the oil in the main hold can never reach a high temperature, owing to the immersion of the vessel, the tanks in the 'tween decks, by being so formed, are kept at a much lower temperature in hot climates than if they extended to the sides In the event, too, of injury to the hull at this part by collision or otherwise, the tank would, under ordinary circumstances, escape injury.

As in other vessels, the machinery is placed aft, and a double bulkhead, marked A in Fig. 12, is fitted before the boiler space, and another at the fore end of the foremost oil compartment. The hold is further separated into two distinct divisions by an additional pair of adjacent transverse bulkheads (B), as shown in the longitudinal plan. The object of this arrangement is to allow of oils of different qualities being carried on the same voyage without any danger of their mixing. Arrangements have also been made by which, with oil in the hold, other descriptions of cargo may be carried in the 'tween decks. With this object expansion tanks (C) formed on the middle deck communicate with the cisterns in the hold, and are capable of being closed, air pipes being fitted to pass through the cover and above the upper deck. Additional expansion tanks (D) built on the roof of the 'tween decks cisterns, within the area of the upper deck hatchways, are for use when both the tanks in the hold and 'tween decks are filled.

A few words regarding the riveting of those parts of the Bakuin required to be oil-tight will be of interest. Owing to the fact that oil has far greater penetrating power than water, and finds its way through seams that are quite impervious to the latter, it has been found necessary to space the rivets in both edges and butts closer than is usual in shipwork, while especial care has to be taken that the holes conform well with each other, and that the workmanship is of a superior character. In the top of the cellular bottom which forms the sole of the cisterns, the plating is $\frac{6}{16}$ in. thick, and the rivets $\frac{5}{8}$ in. in diameter, spaced $2\frac{1}{4}$ in. apart from center to center. In the shell plating amidships, the strakes of which are alternately $\frac{13}{16}$ in. and $\frac{14}{16}$ in. thick, the rivets are $\frac{7}{8}$ in., and are spaced from $2\frac{1}{2}$ in. to $2\frac{3}{4}$ in. apart from center to center in the edges, and from $2\frac{3}{4}$ in. to 3 in. in the butts, Figs. 13 and 14. Where $\frac{3}{4}$ in. rivets are used they are spaced from $2\frac{3}{8}$ in. to $2\frac{1}{2}$ in. from center to center. The rivets connecting the shell plating to the frames are from 6 in. to $6\frac{1}{2}$ in. apart. In the transverse bulkheads the overlaps are riveted with $\frac{5}{8}$ in. rivets spaced $2\frac{1}{4}$ in. apart. This spacing of rivets is closer than in any vessel yet built in this country for oil-carrying purposes, and from what has come under my notice, I question whether much wider spacing of rivets than this—even with the best workmanship—would insure practical oil tightness.

Yet another plan, Figs. 15, 16, and 17, proposed by Messrs. Hawthorne, Leslie & Co., in a vessel which they contemplate building, remains to be noticed. The vessel is fitted with water ballast in the ordinary way, the crown of the tank forming the bottom of the oil cisterns. The machinery is placed aft, and before this the hold is divided by two longitudinal bulkheads, and by transverse bulkheads, into eighteen separate compartments. Under the plan the steel upper deck forms the crown of the tanks, and the ordinary hatchways formed in the deck serve the purpose of overflow tanks, each hatch being made broad enough to serve for the three tanks. The carrying of the oil up to the under side of the weather deck as in this case, and in a vessel being altered by the same firm, is entirely novel, and in view of the possible dangers which it may entail, must be regarded as an experiment.

In addition to the vessels already referred to, a number of other steamers are either being altered, or are proposed to be altered, to carry oil in bulk. Among these are the Chigwell, of 1,699 tons; Presnitz, of 1,639 tons; Marquis Scicluna, of 1,655 tons; Petriana, of 1,672 tons; and Mount Edgcumbe, 1,667 tons. As in these vessels it is intended to carry the oil out to the skin plating, it is necessary to take great pains to secure the oil-tightness of all seams and joints. To effect this purpose Messrs. Hawthorne, Leslie & Co., in altering the Chigwell, removed the whole of the rivets within the boundary of the oil tanks, reamed and countersunk the holes both inside and outside, and reriveted the plates with boiler rivets, as in Fig 14.

The general arrangement of the oil tanks in the Chigwell is shown in Figs. 18 and 19. A middle line bulkhead divides the oil compartments, which extend from the top of the ballast tanks to the under side of the iron upper deck, except in way of the cabins in the bridge, where a separate roof is fitted to the cisterns some two feet below the deck. As already explained, the oil in this vessel is brought into direct contact with the plating of the hull, great pains having been taken to secure oil-tightness in the seams and butts. The ordinary hatchways have been made to serve the purpose of expansion tanks, and the transverse bulkheads are so arranged, where possible, as to admit of each hatch supplying four compartments. It should be added that the oil is prevented coming into contact with the plating of the shaft tunnel by a separate casing built around it.

There are not wanting signs that many of the ship owners of this country are awakening to the necessity of taking immediate steps to secure participation in an industry which is at the present time almost entirely in the hands of foreigners. As I have said, one or two steamers have been already so altered as to adapt them for the carriage of oil in bulk, and a number of other vessels are undergoing the necessary alterations, while some new steamers, specially designed, are being built. The petroleum industry is a growing industry, and promises to open a large field for those who are enterprising enough to adopt the simplest, cheapest, and most expeditious plan of carrying the oil. The following table gives the quantity exported in tons annually from America for the last fifteen years:

Year.	Tons.	Year.	Tons.
1870	324,000	1880	1,247,000
1872	427,000	1882	1,647,000
1874	729,000	1884	1,510,700
1876	717,000	1885	1,531,000
1878	997,000		

If we turn to the consideration of the future of the Russian oil industry, the prospect is still more reassuring. The total quantity of oil refined in Baku annually has been steadily growing in amount. The following figures give the production in tons per year since 1878:

Year.	Tons.	Year.	Tons.
1878	97,550	1882	202,000
1879	110,000	1883	206,000
1880	150,000	1884	348,400
1881	183,000		

Into the method of retailing I do not propose to enter, further than to say that if the oil is to be conveyed to the consumer at the lowest possible price, and the demand thus stimulated to its fullest extent, some such conveyance as the tank wagon recently devised by Mr. Edward Phillips, of Bishopsgate Street, London, will have to be resorted to.

SILVER AND LEAD SMELTING IN COLORADO.

OF recent years the silver and lead smelting industry of Colorado has undergone great development, until to-day the produce of the furnaces of this State forms no small portion of the silver product of the world.

Since the first furnace was started at Black Hawk in 1867, the industry has maintained a steady growth up to the present time. This growth, from the year 1867 to 1877, was but slow. Not, indeed, until the discovery of the Leadville ore deposits was any great activity shown. The opening up of these rich fields gave a great impetus both to the mining and smelting business, and had the effect of turning the attention of prospectors more and more to the development of the silver bearing veins of the country. The result was, many valuable discoveries were made in various sections, and large smelting plants were built to treat the ores at convenient points. A rapid development of the railroad system has also tended largely to build up the smelting business, and especially at central points to which various mining sections were tributary.

The earlier smelting works were invariably located in the immediate neighborhood of the mines, on account of the difficulty of transporting the ore, and had to rely on the section they were in for both fuel and ore; but as transportation improved, these plants were mostly either abandoned or shifted to the valleys, where a more extensive ore market and cheaper fuel and supplies could be commanded.

There are still some of these mountain plants at work, but it becomes year by year more difficult for them to compete successfully with works in the valley, located convenient to fuel and supplies.

The smelting works located in and around Leadville are the only mountain companies which have been to any great extent successful, and these are now finding it very hard to pay the price for ore paid by valley smelting companies. In this section there are in all six plants with an aggregate of 22 water-jacket furnaces, of which 17 are now in blast. About one-half of the ore mined in Leadville is shipped out to be treated; of this quantity a large proportion goes to Pueblo and Denver. At the former place there are three plants with 18 water-jacket furnaces, of which 16 are now in blast, and at Denver there are two plants with 11 furnaces, all in blast.

The other smelting points of importance in the State are as follows: Gunnison, 2 plants, 5 furnaces; Golam, 1 plant, 2 furnaces; Aspen, 1 plant, 2 furnaces; Canon City, 1 plant, 2 furnaces; Durango, 1 plant, 2 furnaces; Reco, 1 plant, 2 furnaces; making a total for the State of 66 furnaces, of which not more than 43 are in blast.

The above figures do not include the furnaces at the Argo Smelting Works, Denver, which are of the reverberatory type.

The style of furnace almost exclusively used in this section is constructed with a rectangular bosh, water-jacketed with cast iron water-jackets. The general construction of these furnaces varies little except in the size of the bosh and in the upper structure.

Fig. 1 is a transverse section through the furnace shed and furnace in use at the Colorado Smelting Works, South Pueblo. These works were erected in 1883, when three furnaces were put in, since when, one more furnace has been added. Being of recent construction, this plant embodies many improvements on the other works of the State as to facility of handling the ore, and are perhaps the best arranged and operated works in the West, and reflect much credit on the able management of Mr. Eilers and his staff.

Fig. 2 is a ground plan showing arrangement of boiler and engine room, furnaces, etc. Steam is supplied for the motive power by three boilers of the horizontal tubular construction, of ample capacity for the work to be performed. In the engine room are two 14 in. horizontal engines driving the blowers, which supply air to the furnaces. The mode of arrangement will be clearly understood from Fig. 2. These engines are each capable of running the four No. 5½ Baker blowers necessary for the four furnaces, so that in case of accident to one engine no delay need occur. The main driven pulleys on the line shaft are provided with friction clutches, so that either may be conveniently connected or disconnected as may be desired.

In this room there are also located an electric light engine and Brush dynamo for lighting the works, together with the usual feed-water heater, feed pumps, etc., making a very complete power plant. In the space between the engine room and furnace shed, a power elevator is placed and driven from the main line shaft. The furnace shed is a frame building with iron roofing; the arrangement of furnaces will be readily understood by the drawing without further explanation.

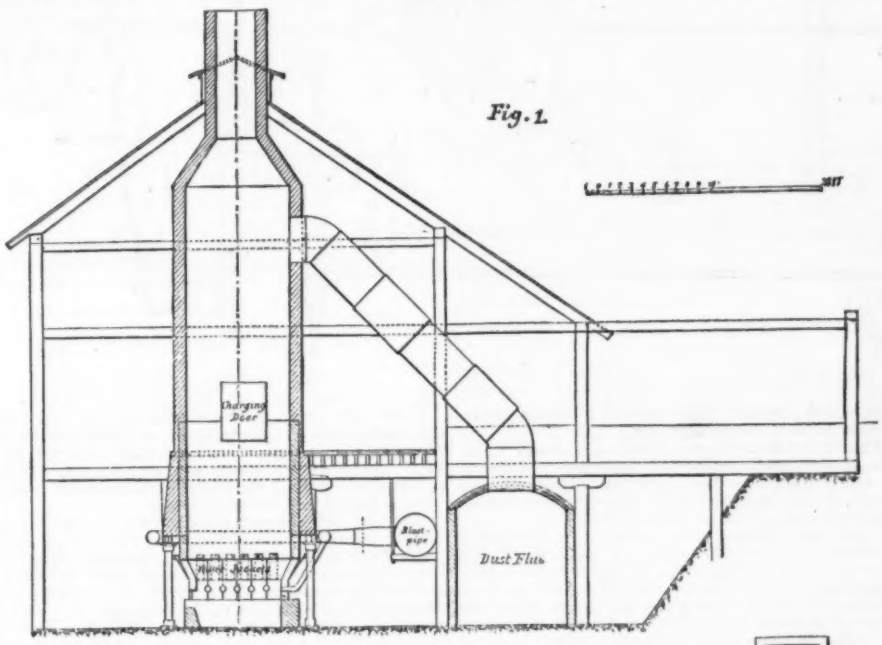


Fig. 1.

Fig. 2.

SMELTING WORKS, DENVER, COL.

The furnaces are of rectangular construction, measuring 7 feet 6 inches by 3 feet inside the jackets, with a crucible 2 feet 6 inches deep. The slagging is done at one end only, no tuyere being used at that end of furnace. The lead well is located about the middle of one side, and is of the usual construction. Each furnace is provided with eleven 3 in. tuyeres, arranged five on each side and on the back end. Above the jackets the upper masonry is carried on four 8 in. cast iron columns, carrying three 7 in. wrought iron beams. The charging door is located 13 feet above the tuyeres, the furnace being charged from both sides of the stack. These furnaces have a capacity of about 60 tons per twenty-four hours.

In addition to what has already been described, these works are provided with a fully equipped sampling mill, a frame building 56 feet by 78 feet, also drying and roasting furnaces, after the most improved pattern. The works are accessible on all sides by rail; the ore to be treated is brought in on a level with the charging floor, while a track on a level with the furnace floor is utilized for the shipment of bullion. These works are largely supplied with ore from the company's mines at Monarch, where a good grade of smelting ore running high in lead is obtained.—*Engineering.*

DESCRIPTION AND THEORY OF THE MOTIONS IN BOBBIN FRAMES.

Flax and its like, and, in general, all fibers that can br spun, must, before reaching the spinning frame, which gives them a proper size and tension, undergo quite a complicated series of operations, with the object in view of forming them into a regular ribbon or sliver, which the jenny has then only to compress still further, while at the same time giving it a twist.

The forming of long staples into ribbons is done in lap machines. In these the laps are spread out upon endless leather belts carried by a table annexed to the machine. The material is thus carried between rollers called feeders, which give it up to combs carried by bars that have a motion to the right and left to an extent a little greater than the length of the rollers. These combs carry the material opposite the drawing rollers, which seize it and pass it in the form of ribbons into sheet iron cans.

The forming of short staples into ribbons is done by

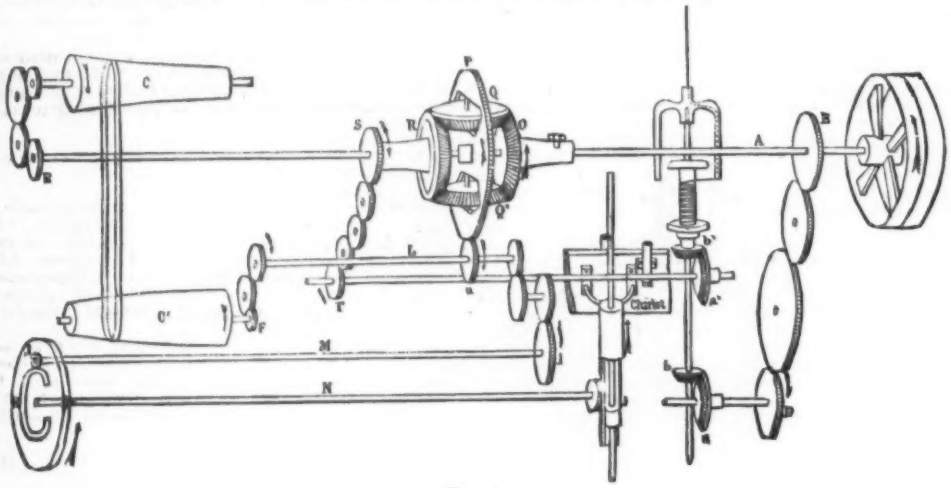


Fig. 1.

machines called carders, which furnish a ribbon analogous to that formed by lap machines.

After this the ribbons are rendered regular and tenuous by means of machines called doubling or drawing frames, which differ from lap machines only in wanting a lap table, and behind which are placed the cans coming from the lap machine or carding frame.

After the last drawing, the ribbon has reached a nearly sufficient degree of regularity; but it is still too coarse to be spun directly, and it is therefore necessary to elongate it further, so as to convert it into a sliver that is but a few fractions of a line thick. As with such a thickness the sliver is very tender, it is given a slight twist in order to increase its strength. With so slight a thickness, it is no longer possible to make the sliver pass into cans, as in drawing it out, since it would get entangled therein, and the twisting would produce helices. In order to overcome such troubles, the sliver is wound upon a bobbin. As for the operation of drawing, that is effected upon a frame, by means of feeders, combs, and drawing rollers arranged exactly as in the lap machine. Upon the whole, this frame differs from the lap machine only in the addition of movements to produce the twisting of the sliver and the winding of it upon a bobbin.

The twisting and the winding of the sliver on the bobbin are effected by a vertical spindle. This latter rests, through its pivoted base, upon a copper step bearing. Above, it is held by a collar in which it revolves with slight friction, and at its upper extremity it is provided with a flier. The bobbin that the spindle passes through rests upon a carriage that has an up and down motion, and which, through such motion, allows the sliver to wind round the bobbin, throughout the latter's entire length, and in a series of spirals. A horizontal shaft, provided with a conical pinion, *a*, actuates a bevel wheel, *b*, keyed to the spindle, and gives the latter a rapid rotary motion from right to left. Another horizontal shaft, supported by the carriage, drives, through a conical pinnion, *a'*, a wheel, *b'*, and revolves in the same direction as that of the bobbin and carries along the latter in the direction of the wheel. The flier and bobbin, then, revolve in the same direction. The upper part of the flier contains an aperture for the passage of the sliver furnished by the drawing roller. Opposite each arm of the flier there is an aperture in the bearing of the latter through which the sliver makes its exit. This latter, guided by a projection on the shoulder of the flier, afterward passes through the hollow arm and runs to the bobbin. The flier, in revolving, gives the sliver the desired twist and winds it around the bobbin. But as the length of cord produced during one revolution of the flier is but a fraction of the bobbin's circumference, it is necessary, in order that this portion of the sliver may be distributed without tension, that the bobbin shall revolve in the same direction as the flier and retard it sufficiently to allow the winding on to be effected. In order to make this well understood, let us suppose that, during one revolution of the spindle, the length of sliver paid out is $\frac{1}{2}$ an inch and the circumference of the bobbin is 6 inches, say 12 half inches. After one revolution of the spindle, one point of the bobbin's circumference will, then, have had to pass over a space of but eleven half inches, the twelfth half inch having served to wind on the half inch of cord produced. The bobbin, during one revolution of the spindle, then, will have made but $\frac{11}{12}$ of a revolution. During the entire time that it takes the carriage to rise, in order to allow the cord to wind from the bottom to the top of the bobbin, the retardation of the spindle by the latter will be constant, say $\frac{1}{12}$ of a revolution per one revolution of the spindle—since, during the entire time of the same travel, the velocity of the carriage has to be uniform.

When the first travel has ended, the carriage will descend. The diameter of the bobbins will then be increased by twice the thickness of the cord; the spirals will therefore be longer; and as at every travel the number of the spirals is the same, the result will be that the second layer will consist of a greater length of cord. It will therefore take longer to wind the latter, since the delivery of the drawing roller is constant. Thus, in the second travel, the carriage will have to run more slowly, and so on in each new travel.

The same is the case with the retardation of the bobbin, which becomes so much the less in proportion as the bobbin is fuller of cord. Let us, for example, consider the bobbin when its diameter is doubled, its circumference being then twenty-four half inches instead of twelve.

Now, at one revolution of the spindle there is produced but $\frac{1}{2}$ an inch of cord, and the retardation of the bobbin, in order to distribute this $\frac{1}{2}$ inch, will have to be $\frac{1}{24}$ of a revolution. During one revolution of the spindle, then, the bobbin will have to make $\frac{23}{24}$ of a revolution.

Thus, in measure as a new layer of cord is added to the bobbin, the velocity of the latter increases, while that of the carriage diminishes.

There are, then, in the spindle frame, two differential motions to be effected—one a retarded one for the carriage, and the other an accelerated one for the bobbin. These two motions are correlatives of one another, and we shall show the arrangements that have been adopted for obtaining them.

Variable Motion of the Carriage.—The shaft, A, which receives its motion from the line of shafting, carries a cogwheel, B, which, through intermediate ones, actuates the wheel, D, keyed upon the shaft that drives the spindles. This shaft is provided with as many conical pinions, *a*, as there are spindles to be revolved. Each pinion, *a*, drives one spindle, through the intermedium of a pinion, *b*, and it is clear that if the velocity of the wheel, B, is constant, that of the spindle will be so too. At the end opposite the pulley, the shaft, A, carries a cogwheel, E, which, through intermediate ones, actuates a cone, C. It is evident that the velocity of the latter is likewise constant when that of the wheel, B, is. Through another belt, the cone, C, drives another cone, C^1. It is easily seen that, through the arrangement of these cones, when the belt is shifted from left to right, the velocity of the cone, C, remaining constant, that of C^1 must diminish, since the diameter of C is diminishing, while that of C^1 is increasing. Upon its axis, the cone carries a pinion, F, which, through an intermediate one, transmits motion to the shaft, L. This latter is provided at its other extremity with a pinion, H, which, through intermediate ones, drives the shaft, M. This latter is provided at the extremity to the left with a small pinion, J, that actuates a wheel which revolves in one direction or the other according as the pinion controls it internally or externally. The shaft, N, keyed to this wheel, reproduces these motions. This shaft is provided with pinions that gear with the vertical racks that support the carriage. Then, according as the wheel, K, revolves in one direction or the other, the rack rises or descends, and thus produces an up and down motion of the carriage. In measure as the belt advances toward the right of the cones, the motion of the wheel, K, and consequently that of the carriage, becomes slower. The carriage, upon reaching one end of its travel, abuts against a device that shifts the belt to the required distance. As for the form of the cones, that is determined by calculation in such a way as to effect, at every travel, the retardation that the carriage must have. Such calculations will be found further along.

Differential Motion of the Bobbin.—A sleeve ending in a bevel wheel, O (Fig. 2), is keyed to a shaft, A. The motion of this wheel is the same as that of the wheel, B. A differential wheel, P, revolves freely around the shaft, A, and is provided with two conical pinions, which are at right angles with its plane and gear with the pinion, O. Again, these pinions engage with the pinion, R, which is provided with a sleeve that moves freely upon A, and which ends in a wheel, S. This latter, through the intermedium of gearings, drives the wheel, I, and, consequently, the pinion, *a*, that actuates the bobbin. As for the differential wheel, that is driven by a pinion, *u*, fixed upon the shaft, L, and revolves in the same direction that the pinion, O, does. It must be remarked that the pinions, O and R, and Q and Q^1, are identical, and that, were it neces-

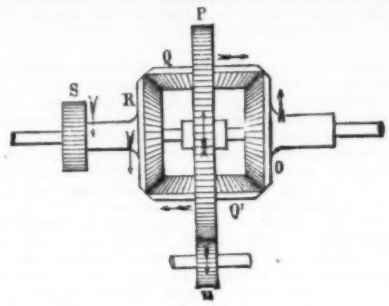


Fig. 2.

sary, either Q or Q^1 might be dispensed with, since either one of them would suffice to transmit the motion. Two pinions are used between O and R, merely to increase the stability of the whole. Now let us see how things proceed. Let us suppose in the first place that the wheel, S, is not revolving. The wheels, Q and Q^1, will then play the role of intermediates, and will transmit motion from O to R in the direction shown by the arrows. In this case, the bobbin will revolve as fast as the spindle, and there would then be no winding on. When the wheel, P, is revolving, it makes less revolutions in a unit of time than the wheel, O. Let us suppose that P makes one revolution every time O makes 10, and let us decompose the motion, for every period of 10 revolutions, as follows: The wheels, P and O, in the first place make one revolution together, and, after P stops, O goes on to make 9 other revolutions. It is clear that, as regards the absolute retardation of the wheel, S, the result will be the same. Now, during the revolution that O and P make together, it is evident that things will proceed as if Q, Q^1, and *o* were interdependent, that is to say, the wheels, Q and Q^1, will not have to revolve in their plane. Their movement around the shaft will have the effect of carrying the wheel, R, with them and of causing the latter to make a revolution in a direction contrary to that which it ought to have.

When P ceases to revolve, the first revolution that O makes will bring back R to its initial position, and, after this, O will transmit integrally to R the 8 revolutions that it remained for it to make.

Thus the effect of every revolution of the wheel, P, is to cause R to lose two of the revolutions that O is making during the same time. If, then, we designate by N the number of revolutions that O makes in a unit of time, and by *n* that which the wheel, P, makes, the number of revolutions made by R in a unit of time will be:

$$N-2\,n.$$

N is constant, and equal to the number of revolutions made by the shaft, A; *n* is variable, and depends upon the diameter of the bobbin.

We shall always be able to determine *n*, then, in such a way that the velocity $N-2\,n$ that the wheel, S, should have shall be proportionate to the retardation to be given the bobbin over the spindle. To this effect, the ratio that should exist between the number of the teeth of the wheels, P and *u*, or between the wheels, P and F, will be determined.

It has been seen that when the belt moves upon the cones from left to right, the velocity of the pinion, *u*, diminishes, and that of the wheel, P, diminishes likewise. Now, in measure as the number, *n*, of revolutions of the wheel diminishes, the number $N-2\,n$, which expresses the revolutions made by the wheel, S, increases. Consequently, the velocity of the bobbin, which depends upon that of S, increases. We have, then, through the arrangement described, the result that it was desired to obtain.

It is clear that, instead of retarding the bobbin, we might give it a sufficient forward motion for the winding on of the cord. For this it would suffice to reverse the direction of revolution of the wheel, P, which would have the effect, at every revolution of the wheel, P, of increasing the velocity of the wheel, S, by two revolutions.

Aside from the fact that there would be no advantage in this, it would have the inconvenience of requiring a greater motive power and of producing a quicker wear of certain parts.

Determination of the Profile of the Cones.—We have said that if the wheel, P, were not turning, Q and Q'

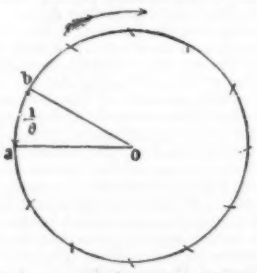


Fig. 3.

would transmit the entire speed of O to S, and that in this case the velocity of the bobbin would equal that of the spindle. This results from the fact that the gearing of the spindles is exactly the same as that of the bobbins; in other words, the number of teeth in

the wheels, B and D, is the same as that in S and T. The result is that the retardation that the bobbins ought to have over the spindle is proportional to that that the wheel, S, should have over B. This granted, let us find what the retardation of the bobbin over the spindle is when the latter is making N revolutions. Let us designate the diameter of the bobbin by d, and the torsion of the cord per inch by ϑ. As ϑ indicates how many twists (revolutions) there are per inch, $\frac{1}{\vartheta}$ indicates, in inches or fraction of an inch, the length of cord produced in one revolution of the spindle. The circumference of the bobbin is πd. On dividing this by $\frac{1}{\vartheta}$, we shall have the number $\pi d \vartheta$, which indicates how many times it contains the length of cord produced during one revolution of the spindle.

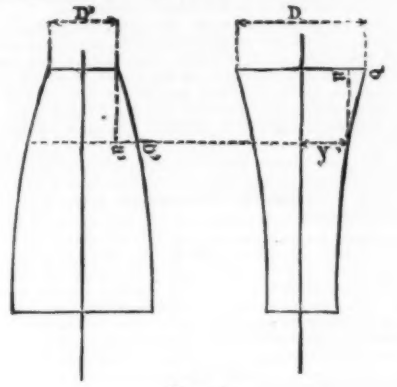


FIG. 4.

Now, if we divide the circumference of the bobbin into as many parts equal to $\frac{1}{\vartheta}$ as it contains, that is to say, into $\pi d \vartheta$ parts, we shall see that when the spindle has made one turn, the bobbin will have to be retarded to the angular extent of $a\,o\,a'$, in order to wind on the length $\frac{1}{\vartheta} = a\,a'$ of cord produced. The bobbin, at every revolution of the spindle, will therefore be retarded $\frac{1}{\pi d \vartheta}$ of a revolution; consequently, when the spindle has made N turns, the retardation of the bobbin in revolutions is $\frac{N}{\pi d \vartheta}$. Therefore, when the wheel, B, has made N turns, the retardation of the wheel, S, is likewise $\frac{N}{\pi d \vartheta}$.

It has been seen that when the wheel, B, is making N turns, if n expresses the number of turns made in the same time by the wheel, P, $N-2n$ is the number of turns being made by the wheel, S. The retardation of the latter over B, then, is $2n$ turns, and we have

$$n = \frac{N}{2\pi d \vartheta}$$

Let us seek n as a function of the number, N, of revolutions made by the cone, C, the belt being at the extremity to the left. (The belt is considered as reduced to a simple line.) Let D and D' be the extreme diameters of the cones. The speed of C being M, that of C' will be $\frac{M D}{D'}$.

The cone, C', drives the differential wheel, through a pinion, F, and intermediate gear wheels, G, u, etc.;

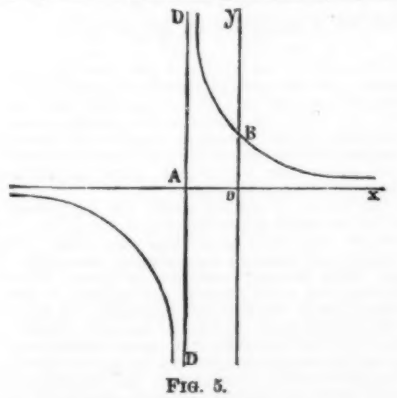


FIG. 5.

but it might be actuated directly, through the pinion, F, by giving the latter and P a suitable number of teeth. Let us designate such numbers of teeth by F and P. We shall obtain the speed of the wheel, P, by multiplying that of the cone, C', $\frac{M D}{D'}$, by the relation $\frac{F}{P}$, which, for the speed, n, of the wheel, P, gives

$$n = \frac{M \times D \times F}{D' \times P}.$$

We have, then,

$$\frac{M \times D \times F}{D' \times P} = \frac{N}{2\pi d \vartheta}$$

an expression that we shall put in the form

$$\frac{2\pi \vartheta M F}{P N} = \frac{D'}{d D} \qquad (1)$$

Now let d' be the diameter of the cord. At every travel of the carriage, the diameter of the bobbin will increase by twice that of the cord, and, after the xth travel, the diameter of the bobbin will be

$$d \times 2 d' x.$$

The retardation of the bobbin over the spindle, and, consequently, that of the wheel, S, over the wheel, B, will thus be for one turn:

$$\frac{1}{\pi \vartheta (d + 2 d' x)}$$

and for N turns:

$$\frac{N}{\pi \vartheta (d + 2 d' x)}$$

The retardation, n, then, will be

$$n = \frac{N}{2\pi \vartheta (d + 2 d' x)}$$

Let us designate by y the radius of the cone, C (Fig. 4), at the point where the belt happens to be at this moment; the diameter will be $2y$. The cone, C, will then have lost in diameter $(D - 2y) = 2a\,b = 2a\,b'$. But what this cone loses in diameter the cone, C', gains. When the diameter of the cone, C, is $2y$, that of C' is $D' + (D - 2y)$. Upon seeking the speed, n, of the differential wheel, P, as a function of the diameter of the cones, we shall find—

$$n = \frac{M \times 2y \times F}{(D' + D - 2y) P} = \frac{N}{2\pi \vartheta (d + 2 d' x)}$$

whence,

$$\frac{2\pi \vartheta M F}{P \times N} = \frac{D' + D - 2y}{2y (d + 2 d' x)}. \qquad (2)$$

The first members of equations (1) and (2) being identical, we deduce therefrom

$$\frac{D' + D - 2y}{2y (d + 2 d' x)} = \frac{D'}{d D};$$

or,

$$x y + \frac{d (D + D')}{2 d' D'} y - \frac{d D (D + D')}{4 d' D'} = 0. \qquad (3)$$

Such is the relation given by the radius, y, of the upper cone after the xth travel. If we consider x and y as the co-ordinates of a curve, this relation will represent an equilateral hyperbola, an asymptote to the axis of the x's and to a straight line, D A D', parallel with the axis of the y's, and having for equation (Fig. 5),

$$x = \frac{d (D + D')}{2 d' D'}.$$

The hyperbola intersects the axis of the y's at a point, B, distant from the origin of the axis of the quantity $\frac{D}{y'}$, equal to half of the large diameter, D, of the cone.

The equation does not include the length, L, of the cones; but it does include two indeterminates, d and d', from which it is easy to free it by introducing into it this said length, L. In fact, if we express only for the abscissa, x=L, the equation must give for the ordinate a value $y = \frac{D'}{2}$, and we have

$$\frac{L D'}{2} + \frac{d(D+D')}{4d'} - \frac{d D(D+D')}{4 d' D'} = 0$$

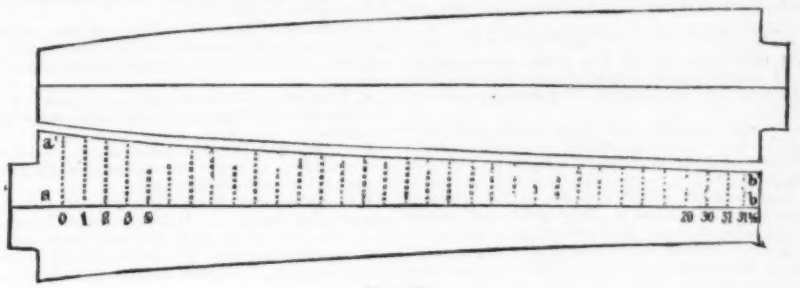


FIG. 6.

whence we deduce

$$d' = \frac{d (D + D') (D - D')}{2 L D'^2}$$

This value of d', carried to the equation, gives after simplifications,

$$x y \times \frac{L D'}{D - D'} y - \frac{L D D'}{2(D - D')} = 0$$

It will be seen that the elimination of the diameter, d', of the cord effects, at the same time, that of the primitive diameter of the bobbin. We shall remark upon this subject that, on supposing that for x = L, y ought to be equal to $\frac{D'}{2}$, we eliminate not only the indeterminates, d and d', but also give the variable, x, another signification. Before the elimination of the indeterminates, x represents a determinate, but variable, number—that of the travels of the carriage. After the elimination, x represents, as y does, a displacement —y representing a motion in the direction of a diameter of the base of the cone, and x a motion in the direction of the cone's axis.

The equation thus gives the profile of the cone as a function of its length and of the diameters of its bases. If, as is generally done, we take the diameter of the large base as double that of the small one (in which case we have $D = 2D'$), the equation will be further simplified, and become

$$x y + L y - \frac{L D}{2} = 0. \qquad (4)$$

It is clear that as the cone thus determined is independent of the diameters of the bobbin and cord, it is adapted to any frame whatever that has to form any sort of cord whatever, with any primitive diameter of bobbin. It will suffice to properly arrange the belt upon the cones at the start, as well as the length of the side motions of the belt at every travel.

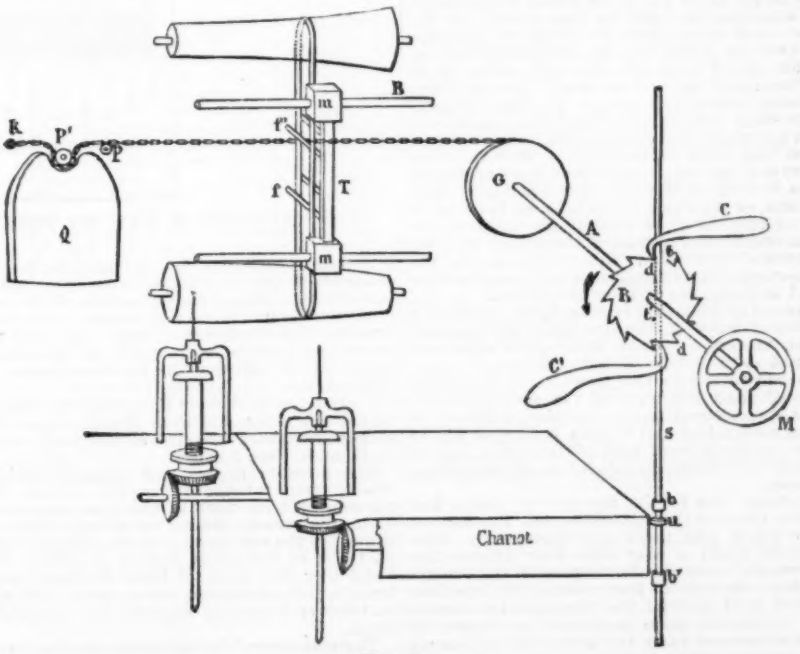


FIG. 7.

Construction of the Profile of the Cones.—Equation (4) solved with respect to y gives

$$y = \frac{L D}{2(L + x)}.$$

Let us suppose that we wish a cone 31½ inches in

length, with the larger diameter of 6 inches. These values, substituted in the equation, will give

$$y = \frac{94{\cdot}5}{31{\cdot}5 + x}$$

Let us take a line, $a\,b$, of 31½ inches in length, divided into inches. At the points of division, let us raise perpendiculars to $a\,b$, and then, in the last equation, successively make $x = 0$; $x = 1$; $x = 2$ . . . . $x = 31\frac{1}{2}$. Let us carry the corresponding values for y that result therefrom to the perpendiculars marked 0, 1, 2, 3 . . . . . 31½; and then, through the extremities, pass an unbroken line. This line, $a'\,b'$, will be the profile required. As it is necessary to leave a little margin to the belt, we have increased the length by one inch at each end

This profile is to be very carefully traced upon a piece of well planed and thick sheet iron, which will serve to guide the instrument that shapes the cone in the lathe.

Shifting of the Belt.—We have said above that the carriage, on reaching one of the ends of its travel, abuts against an apparatus that shifts the cone belt the desired distance. We shall show the arrangement of this apparatus.

A horizontal axle, A (Fig. 7), at right angles with the direction of the frame through which it passes, carries two wheels—one of them a ratchet wheel, R, and the other a pulley, G, with a helicoidal channel. Around this pulley runs a chain, which is fixed to the vertical rod, T. Another chain fixed to this same rod passes over two small pulleys, $p\,p'$. The pulley, p, revolves on an axle fixed to the frame, while the pulley, p', is fixed to the interior of a weight, Q. The chain is afterward fixed to the frame at the point, K. The rod, T, is provided at each extremity with a piece, m, that slides with slight friction upon the horizontal bars, B, which are parallel with the frame. The rod, T, carries two forks, $f\,f'$, between the branches of which runs the cone belt. Two clicks, C C', engage with the teeth of the ratchet wheel, R. The upper one of these acts by its own weight, and the lower one by the weight of its opposite extremity. These clicks are so arranged that when one of them engages with a tooth, the extremity of the other enters a tooth directly opposite. A vertical rod, s, carries two little tappets, $t\,t'$, and two stationary rings, $b\,b'$, spaced a distance apart equal to the travel of the carriage. This rod passes through a stop, u, fixed to the carriage and placed between the rings, $b\,b'$. The figure represents the carriage at about the end of its upward travel. At this moment, the stop abuts against the upper ring, and, through the tappet, t, lifts the click, C. The tooth, d, of the ratchet wheel is thus disengaged. The weight, Q, exerting a tension on the chain, causes the belt to advance toward the left, and at the same time makes the entire system of the axle, A, revolve. But, as the wheel, R, has revolved by half a tooth, it is stopped at the tooth, d', by the click, C', and does not move again until the moment when the stop, u, pressing against the lower ring, disengages the tooth, d'. The extremity of the upper click is then in the center of the tooth, d. The wheel, R, then revolves by half a tooth again, allowing the belt to move forward the same distance as before, and so on at every travel. As for the number of teeth in the wheel, R, that is variable, and depends upon the displacement to be given the belt, and that in turn depends upon the size of the cord. When the bobbin is full, a wheel, M, called a Mendoza pulley, permits of moving the belt back to its initial position, in order to begin another bobbin.—*L'Industrie Textile.*

ACCIDENTS DUE TO THE USE OF MAGNESIAN CEMENTS IN MASONRY.

By MM. LEON DURAND-CLAYE, Chief Engineer, and DELRAY, Engineer (*Ponts et Chaussées*).

IN a circular dated July 18, 1876, the Chief Administration (of *Ponts et Chaussées*) notified the engineers in chief of the Lower Loire and neighboring departments that after experiments made in the harbor of St. Nazaire, as well as in the *Ecole des Ponts et Chaussées* they felt able to authorize, in such structures as bridges, locks, quay walls, etc., in fresh water or in open air, as well as in parts of sea works that are above the high-water mark, the use of Portland cement made in a recently opened factory at Campbon (Lower Loire). On account of this circular, the Bureau of Construction of the work of building a railroad from Questembert to Ploermel accepted the Campbon Works on the same footing as the Longuety Works, at Boulogne sur Mer, or the Famelron Works, at Desvres, as regarded the furnishing of cement for building the arches, of about 14 meters span, of three skew bridges, projected for the river Oust. Because it was near the scene of operations, the Campbon factory supplied the cement used in the arches of these structures.

About the end of 1882, that is to say, one year after the beginning of work on the line from Questembert to Ploermel, movements that were quite abnormal were observed in the arches of these bridges. Fissures were produced parallel to the face; the face courses were separated from the body of the arch; the arch was divided into several parts; the coping stones of the tympans were raised and thrown outside of and to the right of the keystone of each of the arches, and at the same time the abutments rotated above the springing of the arch.

The vibrations due to the passage of trains had only served to increase these disturbances. The fissures widened to 0·01 m. and more, and reached the piers and abutments about a year after they affected the arches. From this time the destruction of the bridges was inevitable. In spite of the presence of iron bars that had been used to bind the tympans, the arches completely disjointed, were weakened by their own weight, and separated from the tympans by fissures several centimeters wide. It became necessary to support them by very resistant centers, until a final decree should order the demolition of the masonry vaults, and the substitution, as the work on the road continued, of metallic girders for masonry bridges.

The engineers who were called upon to study these phenomena attributed them to a swelling of the Portland cement used in building the arches. We give the description of the movements as detailed by Engineer Resal, in charge of the building of the new Orleans lines, in a letter of June 6, 1885, addressed to the President of the Cement Commission:

"On account of the swelling of the cement, the joints of the arch, N C, Fig. 1, enlarged as they broke, and, consequently, have increased the development of the intrados and extrados; the arch necessarily rose at the keystone, C, where a fissure, naturally larger on the extrados than on the intrados, was produced. Another was naturally produced at the springing, N, of reverse direction. In general, this fissure is small, the upper angles, O, of the springer and of the first voussoir being broken and chipped. The same fact is observable in several arches, in the horizontal joints of the intrados of the upper voussoirs, just as shown in the figure. The body, T, of the tympan, carried by the arch, followed its movement of rotation around the point, O, which produced the following results:

1. A general break at the line of separation, O P, between the tympan and the arch is apparent, the lower part of the tympan not having undergone the same deformation as the arch.

2. The plinth of the bridge in the middle of each arch was driven upward. (This rise, which amounts to several centimeters, is quite visible on crossing the bridge.)

3. The joints at the summit of the arch were opened, and the central fissure of the arch extends into the tympan.

4. In general, the tympans show no other ruptures. Nevertheless, in some cases, the middle part between O and P showed disruption.

We have seen that the tympan, T has rotated around the point, O. It follows that the vertical joint, R Q, has shifted to R Q', driving back the pier, M, of the abutment, which has been forced outward. The vertical joint, S V, was naturally displaced, and took in general a direction, S' V, parallel to R Q'. The inclination of this joint is shown in almost all the structures by the successive projection of the stones, the horizontal joints of the abutment pier having been broken; this is very easily seen. All these movements are shown only in such parts as the arch could act upon. This explains why the foundations have not suffered."

M. Resal, engineer in charge of the work, to whom we are indebted for these particulars, observed that the appearance of the transverse elevation indicated a rupture, due to a simple enlargement of the foundation without any sinking. In effect, the transverse dimension of the pier was increased several centimeters, and the fissures were of uniform size above and below. The courses of stone had preserved their horizontality, and the joints of the plinth remained rectilinear.

Finally, the largest fissure, which was opened to an extent of four centimeters, penetrated into the quay wall.

M. Resal adds: "The movement of expansion of the foundations could not be transmitted evenly and in its entirety to the springing courses of the metallic part; the resistance of the bridge was enough to keep almost intact the mass of masonry into which the arches were rabbeted.

"A complete rupture between these springing courses and the foundation ensued. The upper portions of the structure, resting on these springers, for this reason has not suffered as much as has the foundation.

"As for the wing walls of the pier, they have only undergone a limited movement; the drawings of this part of the work show clearly that the known fissures are due to the movement of the first courses, which have dilated, as they lifted vertically the upper part of the wing walls, and pressed them a little back. The fissure followed, in effect, visibly the line of this discharging arch.

"In the right hand pier this last phenomenon alone was manifested, Campbon cement in this pier having only been used for the discharging arch, and not in the foundations.

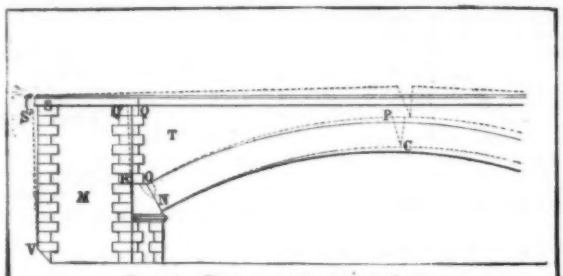


FIG. 1.—BRIDGE OVER THE OUST.

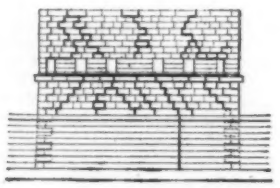


FIG. 2.—BRIDGE OVER THE ETIER DE MAUVES. FRONT ELEVATION OF THE LEFT PIER.

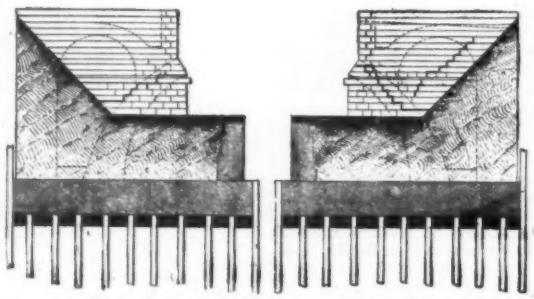


FIG. 3.—SIDE ELEVATIONS OF PIERS OF SAME.

ACCIDENTS DUE TO THE USE OF MAGNESIAN CEMENTS IN MASONRY.

The fissures in the left hand pier having apparently remained unchanged for a certain time, a very liquid grouting of cement of proper quality was injected therein. At first this operation seemed to produce good results, and for nearly a month the face of the abutment remained intact; then all the joints reopened, and the upturning movement went on as before, although with less intensity.

"In the month of October, 1885, the right hand pier presented the same appearance as it did at the beginning of the year, and before the injections. Only, if the number of fissures was almost the same, their average width was only one half as great. Finally, a concluding visit, made during the month of January last, showed that the fissures, closed by new injections, had only opened an insignificant amount, about a half millimeter in three months, and, under these conditions, it was decided to throw open the bridge to travel.

"The phenomena observed in the masonry of the Etier de Mauves bridge can unhesitatingly be attributed to the use of Campbon cement. The hypothesis of a movement in the foundation piles must be abandoned, as it is proved that there was not—in the right hand abutment—any vertical sinking or horizontal displacement in any direction whatever, nor any angular movement around an axis of rotation. Moreover, the piles had been driven until they were immovable."

We have also collected numerous examples of analogous accidents produced in other works of art or in constructions of civil engineering, due to the use of Campbon cement.

Without speaking of inclosure walls completely wrecked by a pointing on one face of Campbon cement; of tombstones in the cemetery of St. Nazaire, joined

with Campbon cement, which were lifted and raised from their bases; of stones broken in many walls on account of the unevenness of the layer of mortar of Campbon cement in the joints; we will cite, to restrict ourselves to more serious disasters, those which were produced in the Rennes central house, and whose effects appeared most strikingly in the pavement.

Under the arcades of the basement of an interior court, the pavement of Campbon cement had forced out of line with the face of the wall blocks of granite measuring 2·95 m. in length by 0·35 m. in height and 0·72 m. in width. These stones, raised and tilted, had drawn with them a portion of the stone wall, and several of the granite piers of the arches were broken and detached from the mass.

In a shop in like manner paved with Campbon cement, on the ground floor of the same house, two foot-stones of granite were disjointed and driven outward a half centimeter. The pavement, cut in 1880 to leave five centimeters between it and the wall, dilated so much that in 1884 the cracks were almost entirely closed up.

We give finally another case that refers directly to public works. Campbon cement was employed along with Boulogne cement in the construction of small brick arches that connected the trusses of an iron bridge, established by the efforts of the local administration over the Seine, between Douges and Savenay (Lower Loire). On the right half of the bridge, where Boulogne cement was used, the walls are perfectly intact and the joints are in good condition; while on the left half, the Campbon cement mortar which unites the bricks has given away, and expanded so that fissures appear in the masonry, with a raising and upheaval of the borders of the foot path.

The analyses made at different times in the laboratory of the *Ecole des Ponts et Chaussées* of samples of Campbon cement, sent by the proprietors of the factory, or by engineers to whom the product was offered, have always shown a high percentage of magnesia, which from the first had attracted the attention of the engineer charged with the superintendence of the laboratory of the *Ecole des Ponts et Chaussées*, and had caused reservations on his part as to the way in which Campbon cement, a product not yet thoroughly tested, might act in practice.

We give below a table of the results of these analyses:

Date of Report of Analysis.	Percentage of Constituents.								
	Sand.	Silica Combined.	Alumina.	Ferrous Oxide.	Lime.	Magnesia.	Sulphuric Acid.	Loss on Heating.	Total.
Jan. 15, 1876....	1·05	15·00	11·15	2·40	52·05	16·20	0·45	1 10	100
April 12, 1876...	1·05	14·80	8·00	4·60	47·30	24·30	0·60	0·40	100
Dec. 22, 1883..	1·05	18·30	2·95	3·60	44·80	28·15	0·30	1·90	100
June 28, 1884...	0·35	20·70	3·35	3·65	43·30	26·70	0·15	1·80	100
April 29, 1885...	0·80	18·20	4·60	4·15	43·95	26·50	0·45	1·35	100

The swelling of Campbon cement coincident with a large amount of magnesia has naturally been attributed to this magnesia. This should be the line of investigation by the special commission on cements in seeking the causes of the accidents described.

Cements of known good quality were placed in paste in tubes of thin glass, some in the natural state, others mixed with calcined magnesia, in amounts varying from 2% to 35%. In the first series of experiments the magnesia was calcined separately, and mixed after cooling with the cement for the tests; in a second series the magnesia and cement was first mixed, and the mixture was brought to a red heat in a special apparatus.

Other tubes were filled with pure cement paste.

Half of the tubes were kept in the open air, the other half were filled with water. After an interval, often very short, varying with the amount of magnesia and its degree of calcination, the tubes filled with water split under the action of the magnesia, while the tubes kept in the open air remained intact, as did the others, whether filled with water or not, which contained pure cement.

Although the results were not strictly comparable, the strength of the different glass tubes not being always the same, it may be of interest to give some details of the work.

Tubes containing mixtures of 35%, of 25%, and of 15% of magnesia, calcined some at a red and some at a white heat, were immersed on October 23, 1885. On the morning of the 27th the first tube broke, and the others successively, so that by the 28th no tube was left whole.

Mixtures of 10% and of 5% prepared on November 3 broke, the first ones between the 7th and 12th, the second ones between the 21st and 23d.

Finally, mixtures made on December 16 and placed under water in tubes on that day, broke the tubes on the following days:

Percentage of magnesia with Boulogne cement.	Nos. of the tubes.	Nature of the Mixture.		
		Cement and magnesia calcined together at a red heat for 12 hours.	Cement and magnesia calcined separately at a red heat for 12 hours.	Cement and magnesia calcined separately at a white heat for 12 hours.
10 per cent.....	1	Dec. 25, 1885.	Dec. 26, 1885.	Dec. 24, 1885.
" "	2	" 29, "	" 28, "	" 26, "
4 per cent.....	1	Feb. 2, 1886.	Feb. 3, 1886.	Jan. 4, 1886.
"	2	" 4, "	" 5, "	" 5, "
2 per cent.....	1	" 8, "	Tubes unbroken.	Tubes unbroken.
" "	2	" 8, "	April 1, 1886.	April 1, 1886.

Thus it appears that mixtures of cement and magnesia act in the same manner as magnesian cement, and undergo an irresistible swelling on contact with water.

So that no doubt could be cast upon this comparison, a last comparative test was made upon a sample of Campbon cement, side by side with a Boulogne cement mixed with 25% of magnesia. Pastes made with each sample were placed in similar tubes, in columns about 0·80 m. long, enough to give grounds for hoping to see the swelling of material, not only by the rupture of the tubes, but also in the dilation of the columns. Water was then poured into the tubes.

The tube containing the mixture of Boulogne cement and magnesia split after a few hours, and showed, eventually, numerous fissures, some transverse, others helicoidal, demonstrating clearly the longitudinal force exerted by the material in swelling.

The same results were produced upon the column of Campbon cement, although more slowly, without doubt because the cement was already somewhat old and air slaked. Ten days elapsed before the tube broke, but the resemblance of the phenomena was striking.

These two columns of cement, after three months, were stripped of their glass covering, and were plunged, unprotected, into water. The dilation they experienced, rendered visible by means of a multiplying apparatus, continued, and had not fully ceased at the end of a month.

Finally, the samples of Campbon cement, mixed into paste, sent by the engineers of the port of Vannes, and kept for several months in the laboratory of the *Ecole des Ponts et Chaussées* without accident, swelled up as soon as they were immersed in water, breaking the glasses containing them. Another glass that was not immersed, and had not broken by November 27, having been left in a damp room, was found broken on the 22d of the following December.

The experiments here summarized prove clearly that the large proportion of magnesia contained in the Campbon cement is the cause of the accidents to the structures where this product has been used.

The rock from which the cement is made contains a large percentage of magnesia, which, during the calcination, doubtless does not combine completely with the silica of the rock. In contact with water this magnesia, dehydrated from the calcination, absorbs water but slowly. The length of time of hydration varies with the degree, and also, without doubt, with the duration, of the burning. The hydration is accompanied by a considerable increase of volume, that produces the swelling of the mortar.

The time after which the phenomenon begins to show itself in mason work depends also on the relative abundance of water coming in contact with the mortar. It has been seen that cement mixed to good consistence, and kept in the air, did not swell at all if the surrounding atmosphere was only dry; that it swelled slowly in wet air; and that if the substance was plunged into water, the swelling appeared so quickly as to break the enveloping glass in a few days.

Masonry laid in cement mortar containing much magnesia, such as the Campbon cement, may therefore be secure from accident if erected in a perfectly dry place; but as soon as it is exposed to the action of water, it must necessarily perish on account of the swelling of the mortar, after a time varying with the abundance of water brought in contact with it. Now, as it is very rare, especially in public works such as bridges or maritime structures, that mortars shall not be exposed to the action of humidity, it may be asserted that all masonry in which cements of this nature are used is destined to be destroyed.

This example, on the other hand, shows with what distrust we should have recourse to products whose chemical composition varies from the usual proportions, unless they have been tested and proved by long usage.

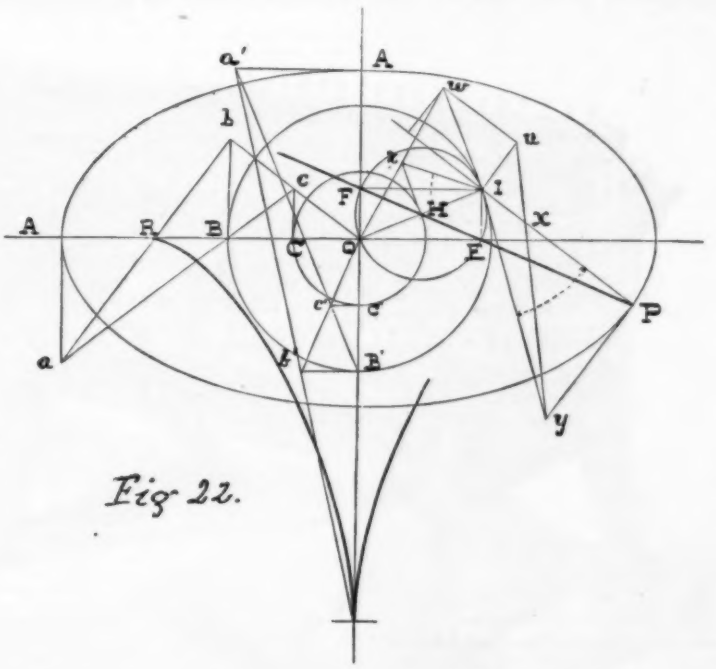


Fig. 22.

Now, EOF and EJF are two equal and similar right angled triangles together forming a parallelogram, whose diagonals EF and OI bisect each other at H. And since EF is constant, OH and OI will also be constant, and the four points E, I, F, O, always lie upon the circumference of a circle, the path of whose center H is an equal circle, while the point I also lies always upon the circumference of a circle of twice the diameter.

Therefore the points E and F move precisely as though they were the extremities of a diameter of a circle rolling within another of double the size; so that the ellipse thus generated may, in fact, be regarded as a special case of the hypotrochoid.

In order to find the center of curvature at P, let us assign any velocity, Hz, to the middle point of EF. The direction of this motion will be perpendicular to OHI; and the instantaneous axis will also have a motion Iw perpendicular to OI and equal to twice Hz; which has a component Iu perpendicular to the normal.

The angular velocity of the trammel bar about I is represented by the angle HIz, to which the angle PIy must be made equal, thus determining the magnitude of Py perpendicular to IP. Then uy cuts the normal in x, the required center of curvature.

It is evident that this elliptograph can be effectively operated by turning a crank, OH, pivoted at H to the trammel bar; by which addition the bar will be compelled to pass, without halting, the "dead center" positions when the bar and the crank coincide. And we are thus enabled to find the maximum and minimum values of the radius of curvature, at the extremities of the minor and major axes respectively.

Thus, when the bar PEF occupies the position ABO, the crank will lie in the position OC. Let its pin C have the motion Cc; then the bar will turn about B as a fulcrum, A moving perpendicularly to A and B with a velocity limited by drawing cB and producing it to cut the perpendicular at A, in the point a. The motion of the instantaneous axis, as before found, will be represented by $Bb = 2\,Cc$; and ba cuts AB in R, the center of curvature.

Then from similar triangles, ABa, BCc, we have:

$$\frac{Aa}{Cc} = \frac{AB}{Bc} : \text{but } Cc = \tfrac{1}{2}\,Bb, \therefore \frac{Aa}{Bb} = \frac{AB}{2\,BC} = \frac{AB}{BO}.$$

And from similar triangles, ARa, BRb, we have:

$$\frac{AR}{BR} = \frac{Aa}{Bb'} = \frac{AB}{BO} : \text{or in the form of a proportion,}$$

$$AR : RB :: AB . BO$$

whence $AR : AR + RB :: AB : AB + BO$

or $AR : AB :: AB : AO.$

By a construction precisely similar, we find R′ the center of curvature at A′ the extremity of the minor axis, when the bar PEF lies in the position A′OB′: and deduce the proportion

$$A'R' : R'B' :: A'B' : B'O$$

whence $A'R' : A'R' - AO :: A'B' : A'B' - B'O$

or $A'R' : A'B' :: A'B' : A'O.$

Thus these values are shown to correspond with the analytical deductions, that the radii of curvature at the extremities of the axes are respectively equal to half the parameters of those axes.

[Continued from SUPPLEMENT, No. 563, page 9000.]

RADII OF CURVATURE GEOMETRICALLY DETERMINED.

By Prof. C. W. MACCORD, Sc.D.

NO. VI.—THE ELLIPSE.

THE ellipse is a curve which can be constructed in many different ways; for our present purpose we will consider it as traced by the familiar instrument known as the elliptical trammel, whose operation is illustrated in Fig. 22. The marking point P is carried by a rigid bar, of which two points E and F slide respectively along the major and the minor axes: the distance PE being equal to half the minor axis, and the distance PF to half the major axis, of the required curve, whose center is O.

At E, erect a perpendicular to EO, and at F a perpendicular to FO; these intersect at I, the instantaneous axis, and PI is normal to the curve.

RAMIE.

CULTURE, DECORTICATION, USES.

THE value of the ramie as a textile plant is now universally conceded, and everything leads to the belief that, when the agricultural production of it has once been made sure of, this vegetable material will find a large market, by reason of its price and its qualities of strength, brilliancy, and incorruptibility. The specific name of *tenacissima* given to this textile is very *apropos*, since, if we express its resistance to traction by unity, that of hemp will be one-third; that of flax, one-quarter; and that of silk and cotton, one-sixteenth. On another hand, while these latter—silk excepted—consist of very short fibers, the filaments of ramie are long and unbroken. Finally, ramie is superior to flax and hemp by reason of its resistance to twisting, its elasticity, and its incorruptibility. In a word, it yields only to silk. So the attempts that have been made to utilize it date back to quite a remote

epoch; but, although these have been pursued with laudable perseverance, the methods proposed for the decortication of the plant have not proved practical.

In fact, the solution of this problem presents one great difficulty, and this has caused many failures, and has prevented the ramie from taking that rank among textile fibers to which its properties assign it; we mean the extreme tenacity with which the gum unites the filaments of the plant, and prevents the separation of the fiber from the wood and epidermis.

The first attempts to cultivate the ramie plant on a large scale in France and Algeria date back to 1868. At that epoch the harl had to be obtained by hand, and hence the product was very small, and the net cost very high in proportion to the quantity of fiber extracted, this not exceeding a pound and a half per day. Under such circumstances, China, where men are paid five cents per day, was the only country that was capable of putting ramie into the European markets at a price at which it could be touched.

What precedes will show the importance of the researches made with a view to substitute mechanical decortication for manual labor. In the first place, retting was tried, but without success, because of the alteration caused by fermentation. Then came a few machines which gave but a small product, and which were followed by chemical processes, for which hundreds of patents were taken out. At present, experiments are still being made in this direction in America. The treatment consists in macerating the ramie stalks in a hot akaline solution, thus requiring a large bulk of water to be kept boiling. Among recent processes, the treatment by concentrated alkalies at a high pressure, due to Mr. Fremy, and decortication by steam, for some little time fixed the attention of interested parties, who finally appear to have given their preference to the mechanical method.

After devoting many years to a study of the question, and after making numerous experiments, Mr. A. Favier came to the conclusion that all former researches had been conducted from a false starting point, and, proceeding from another basis, was led to substitute decortication of the plant in a dried state for treatment of the fibers in a green one. In all former machines, an endeavor had been made, in fact, to crush the central wood in a single operation, and to simultaneously remove the epidermis in order to obtain, in a disintegrated state, the liber that was to give the harl. This was the cause of all the want of success.

In fact, to crush a stalk that is sometimes as thick as the thumb, between fluted rollers, necessarily requires the use of considerable force; and to free such stalk from all the internal wood without damaging the surface appears to be very difficult when it is reflected that the fragments of the wood, having no way of escape, can only make their exit through fissures made in the bark, and the harl, being cut or mashed at different points, through the crushing, must be subject to considerable waste. Finally, the crushed wood goes to the heckles along with the fiber, notwithstanding the action of the scutchers, and renders the harl almost unworkable.

Despite such drawbacks, the problem of decorticating ramie in a green state appears to be very seductive at first sight, especially in the Indies, where the dampness of the air renders it difficult to dry the plant. This latter must be treated in a herbaceous state, since then the sap is still liquid, and no species of desiccation has been able to affect the elasticity of the stalks. Now, under the burning sun of some countries in which the ramie grows, the stalks become so stiff in forty-eight hours after being cut as to interfere with the operation of a machine designed to treat the plant in a green state. In hot and moist countries, the same evil effects are produced by fermentation. The result is that it is necessary to decorticate a crop within forty-eight hours after it is gathered.

As for decortication in a dried state (which is possible, it is true, in countries whose humidity is not sufficient to prevent the desiccation of the stalks), this permits of working the crop during the entire year.

It is with a view to obtaining such a result that Mr. Favier has endeavored to effect mechanically, with dried stalks, the work performed by hand with green ones by the Chinese, that is to say, the detaching of the bark and removal of the brown pellicle that covers it. The apparatus by means of which he has solved this problem consequently consists of two parts, the operation of which is so distinct that each might, if need be, work isolatedly.

The apparatus, which is shown in the figure in its complete form, consists of a frame 11½ ft. long by 2¾ ft. wide, 3 ft. of the length of which is taken up by the first part of the system, called the "decorticator," this being followed by the second part, called the "breaker."

The decorticator consists of two pairs of vertical rollers placed upon a table in front of the machine. These are provided with a peculiar covering, and are set in motion mechanically. Their object is to seize the stalks that are presented to them, and to introduce these automatically into a small and extremely simple device called a jaw. This latter is provided with a knife designed to split the stalks from one end to the other, so as to permit of their being opened in order to expose the wood. This method of operating constitutes the principal peculiarity of the invention.

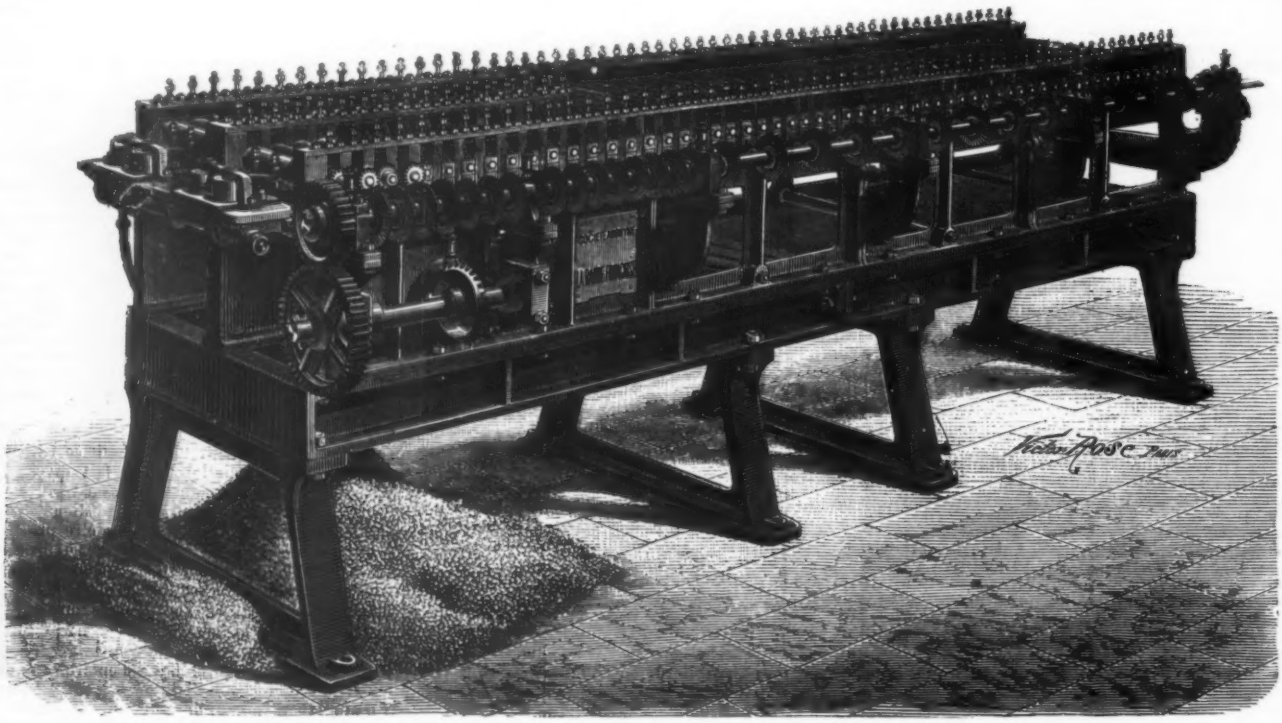
As soon as the stalk has been split, the internal conformation of the jaw obliges the stalk to open and extend in the form of a ribbon that shows the wood on one side and the bark on the other. This ribbon is simple or formed of two parallel parts, according to the position of the knife. Beyond the jaw there are several pairs of solid cylinders that serve to flatten the stalk, and effect the separation of the bark from the wood by breaking up the resin that unites them, so as to form two superposed ribbons—one of wood and the other of bark, but entirely detached. Next comes a series of crushing rollers having coarse flutings, and designed to break the wood into small fragments that fall under the machine.

As may be seen, the decorticator is very simple, and the same is the case with the breaker, which consists solely of a series of finely fluted rollers, whose graduation depends upon the disintegration to be obtained. Only the bark passes between these rollers, which bruise it without injuring the fibers, and deliver it at the end of the machine in the state of harl, whose parallel fibers contain neither wood nor epidermis. This operation takes but two seconds, since all the parts are rotary and allow a high speed to be reached. The machine is run by two men, one of whom introduces the ramie, and the other of whom removes the fiber.

It is estimated that the produce of this mechanical operation is 20 per cent. of raw harl, disintegrated and freed from the greater part of its resin. Moreover, it gives two by-products, viz., broken wood capable of being used in the manufacture of strong, grayish paper, and about 11 per cent. in weight of tannic pellicles that form an excellent compost.

These machines are capable of treating 470 pounds of dried stalks per day of 12 hours, and of yielding 95 pounds of harl. The work absorbed is that of half a horse, and the net cost, leaving aside the general expenses and interest on the machinery, is estimated at $25 per ton of harl produced.

We shall not dwell upon the question of the industrial use of ramie, which is adapted to purposes as varied as they are numerous. Its qualities of incorruptibility, brilliancy, flexibility, and strength guarantee it an extensive use in the rope industry and in the manufacture of sail canvas, which absorb three-fifths of the hemp consumed in France. It can be easily mixed with cotton for making damasked fabrics, and it is superior to flax and hemp for the manufacture of fine, damasked table linen. Moreover, it takes dyes perfectly, and is adapted to all shades, even the most delicate. In a word, according to the mode of preparation of its filaments, it is adapted to the manufacture of fabrics in general, from packing cloth up to tissues simulating silk.—*Revue Industrielle.*



MACHINE FOR DECORTICATING RAMIE.

THE French African cable has been completed to the Congo.

A YEAR'S CENTENARIANS.

THE completion of his 100th year by M. Chevreul gives exceptional interest to the following list of centenarians who have become known during the last twelve months. The record is rather notably rounded by its comprising the period between the death of Sir Moses Montefiore, in July last year, and the celebration of the Chevreul centenary at the present time.

September, 1885.—Mrs. Drake (1), residing near Manchester, completed her 100th year on the 27th of this month. At the age of 22 she was married to a trooper of the 12th Light Dragoons, whom she followed through the whole of the Peninsular campaign. She was also present, as a nurse, on the field of Waterloo.

October, 1885.—William Grant (2), a small farmer living near Newry, died on the 5th of this month at the age of 107. He was working in the fields within the previous two months. On the 15th the funeral of Job Formston (3) took place in Malpas Churchyard, Cheshire. "Old Job" was in his 102d year, and his memory was unimpaired to the last. Mrs. Haggarty (4), a native of Ireland, died at Houston, near Paisley, at the age of 100.

November, 1885.—At Jersey, on the 28th of this month, died Mrs. Sarah Robinson (5), in her 105th year.

December, 1885.—On the 4th of this month an elector of the Saffron Walden Division, named Nicholson (6), although in his 103d year, traveled nearly three miles to record his vote. On the 8th died John Butterworth (7), an inmate of Ormskirk Workhouse, at the age of 104. To the last he had the use of all his faculties. Mrs. Townsend (8) died at Faringdon, in Berkshire, in her 103d year. This lady also retained her faculties to the end. On the 23d a gathering of aged people at Ovington Hall, Leicester, included an old woman named Ann Hings (9), who had nearly completed her 101st year, and remained in excellent health and spirits.

January, 1886.—In this month, at the age of 103 years, died Bridget Hendry (10) in the Manchester Workhouse at Crumpsall. Only a few months before her death she was able to walk from Crumpsall to Manchester.

February, 1886.—David Pugh (11) died at Caerawo, Montgomeryshire, at the age of 102, having worked at his trade as a joiner until a few days previously. A widow named Mary Francis (12), of South Cornelly, Swansea, celebrated her 101st year. She still enjoyed remarkable vigor of mind and body, and could thread a needle without spectacles. Mrs. Johanna Nolan (13), a widow in her 102d year, was living at this time at Hensingham, in Cumberland. She retained a distinct recollection of the battle of Vinegar Hill, fought in 1798, when she was 13 years old. This old lady had only recently broken her arm, and walked two miles to have the limb set at the Whitehaven Infirmary. Had just discarded the splints, and "hoped to be at work again in a few days."

March, 1886.—On the 20th of this month died Mr. George Stirton (14), of Coupar Angus, at the age of 101 years. He was probably the oldest Freemason in Europe, having been a member of his lodge for 78 years. Mrs. Mary Hollendrake (15) died at Shipley, in Yorkshire, aged 102 years. Mrs. Smalley (16), widow of the Reverend Cornwall Smalley, died at East Thurrock Rectory, Essex, in her 103d year. Mrs. Harris (17) died at Paglesham, in the same county, at the age of 100. Mrs. Atherton (18) this month celebrated the completion of her 100th year at Billericay. Miss Heathorn (19), locally known as "The Maid of Kent," completed her 103d year at Maidstone. Mrs. Abbot (20) died at Portsmouth on the 26th, at the age of 101 years and nine months.

April, 1886.—Abraham Partridge (21) was born at Bristol on the 5th of April, 1786, and was living during this month in a workhouse at Liverpool. He has hereditary claim to notice, his father, a Herefordshire man, having died at the age of 105, and his mother, a Scotchwoman, having lived to be 102. A sister (22) of Partridge was also still living at the age of 102 years. Mary Ann Mullender (23) was buried at Brighton on the 28th, aged 102. Mrs. Ann Occomore (24) died at Red-

bridge, in the New Forest, within a few days of completing her 102d year.

May, 1886.—Mrs. Grosvenor (25), residing at Penygloddfa, North Wales, attained her 102d year. On the 12th (during the Queen's visit to Liverpool) a dinner was given to 1,000 poor people in St. George's Hall, one of the guests (26) being an old woman in her 103d year. Mrs. Mary Meredith (27), a widow, who resided in the Welsh village of Llangrove, died in her 104th year, being remarkably hale to the last.

June, 1886.—On the 2d a maiden lady, named Dunk (28), died at Chartham, near Canterbury, at the age of 100 years. Died also Mrs. Mary Collett (29), at Islington, aged 100.

July, 1886.—A Waterloo veteran, John Mackay (30), late of the 42d Highlanders, died at the Royal Chelsea Hospital on the 7th, at the age of 102. On the 8th, at Hexham, died Mrs. Hannah Wilkinson (31), aged 100 years and 8 months.

August, 1886.—Mrs. Sarah Marshall (32), a widow residing at Nantyglo, died this month, at the age of 107 years. She was baptized on the 11th of May, 1779, the certificate being in the possession of the vicar of the parish. Joseph Gathercole (33) died in Bury St. Edmunds Workhouse at the age (as was believed) of 104 years. He had been an inmate of the workhouse for 50 years.

Of the thirty-three instances given—of course the list is by no means exhaustive—no fewer than twenty-four are those of women, of whom nine were still living at the time of their several records. Of the nine men, only two survived.

In addition to the above, six deaths have been registered in Ireland during the past three months at the following ages: One at 101, one at 102, two at 103, one at 104, and one at 112 years respectively.—*St. James's Gazette.*

HOME-MADE WINES AND DRINKS.

THE flowers and berries of the elder (*Sambucus*) have been made use of for wine making from very early periods. The best known of the elder species is the common black elder (*Sambucus nigra*), which is a native of this country, and very generally diffused. It is a small tree, or rather bush, with an irregularly but oppositely branched stem, and it grows with the greatest rapidity. The cream-colored flowers have a sweet but rather heavy smell; the fruit is a globular, purplish-black berry, with a red stalk. The variety mostly cultivated for wine making is the one above mentioned, but the berries of the green and yellow are also applicable to the purpose. The elder requires a good soil, a moist situation, and free exposure to light and air.

Elder-flower Wine is made from the flowers in this manner: (1) Gather the flowers on a dry day; remove all stalks, and to every quart of flowers allow one gallon of water and three pounds of loaf sugar; boil the sugar and water for a quarter of an hour, then pour it on the flowers, and let it work for three days; then strain the wine carefully through a hair sieve, and put it into a cask. To every five gallons of wine add half an ounce of isinglass, dissolved in cider, and three eggs (whites only) beaten up; close up the cask, and stand six months before bottling off. (2) Boil eighteen pounds of powdered loaf sugar in six gallons of spring water; beat up the whites of two eggs, and add; skim very thoroughly, and put in a quarter of a peck of elder flowers, picked from their stems; take off the fire, and stir until cool, then add four tablespoonfuls of yeast and six spoonfuls of lemon juice, strained and free from pips; mix well with the liquor by stirring twice daily for four days. Stone six pounds of Malaga raisins, and put them into a well cleaned out cask; pour the wine upon them. Stop up the cask closely, and keep it in a rather warm place. If made in July or August, bottle off in February or March. This wine, when well made, very much resembles Frontignac.

Elder-flower Vinegar.—To every half peck of the flowers, free from stalks, put a gallon of strong ale vinegar; set in the sun in a stone jar for a fortnight, then filter through a flannel bag; bottle off into quite small bottles.

Elderberry Wine.—(1) Gather the berries when quite ripe, on a dry day; pick them off the stems, and bruise them with your hands. Strain the juice; let the liquor rest in glazed earthenware pans for twelve hours to settle. Allow to every pint of juice a pint and a half of water, and to every gallon of the mixed water and juice three pounds of good moist sugar. Put it over the fire in a large saucepan, and when it is ready to boil, clarify it with the whites of four eggs. Let it boil for an hour, and, when nearly cold, put in some yeast to work it; pour it into the cask, reserving some of the liquor to fill up the cask with, as it sinks with working. If you have about ten gallons or so, it should be fit to bottle off in two months' time after it has been closed down. Keep at least a year in bottle. (2) Gather the berries when quite ripe, and in dry weather. Pick them clean; put them into a copper with half a gallon of water, and keep up a slow fire until the berries sink, then strain the juice through a hair sieve, and to every gallon of it allow three gallons of soft water, and to every gallon of the mixed liquor three pounds of good moist sugar. Put back into the copper, and boil for an hour, skimming thoroughly; draw off into a tube, and, when it is about 70°, put a toast spread with yeast into it, and let it work for forty-eight hours, or longer if necessary; pour it or draw it off if you have a tap in your tub, as should be the case, into the cask which is to hold it, and if you have eighteen gallons of liquor, add one ounce of cloves, two ounces of allspice, two ounces of Jamaica ginger, and one ounce of sweet almonds, all bruised. Bung very slightly until fermentation is quite over; then close down tightly, and tap in three months.

(3.) Old recipe: Put the ripe picked-over berries into an earthen pot; put this into a copper with sufficient water to come up about two-thirds of the height of the pot, which is about as far as the berries should reach inside; be careful that no water touches them. Make a gentle fire, and keep the pot in the water till it is quite hot; then take it out. Pour the berries into a coarse cloth, strain the juice, and put it into a large saucepan; to every quart of juice allow a pound of good moist sugar; let it boil, and skim well. It should boil until rather thick, then pour it into a jar. Put sixty pounds of raisins into a cask, and fill it up with water; let it stand for a fortnight; stir it well every day; then pour off the liquor into a clean cask that just holds it. It should stand until it has done hissing; then bung it down close, and stand until fine. To every gallon of this liquor allow half a pint of the elder sirup; mix well, and when it has fined down, rack off into another cask; bottle off after three months.

(4.) Chop a quantity of Malaga raisins quite fine; allow a quart of water to every pound of raisins, and put raisins and water into an open tub; cover over with a double cloth, and let it stand for nine days, stirring up each day. Then draw off the liquor as long as it will run, and press the raisins to get out the remainder of the juice; mix all together in a barrel. To every gallon of liquor allow a pint of the juice of elderberries, prepared simply by mashing the berries with the hands, and straining off the juice. Stop down close, and stand for six weeks, then draw off the fine liquor, and to every gallon add half a pound of moist sugar. Stand again until quite fine, and then bottle off. Keep in a cool cellar for use.

(5.) Take thirty pounds of Malaga raisins, add eight gallons of water to them, and allow to steep for twelve days; draw off the liquor, and put it into a copper with two gallons of elderberry juice; boil for ten minutes, removing all scum as it rises; then add seven pounds of moist sugar, half an ounce of allspice, half an ounce of cloves, and two ounces of Jamaica ginger, all well bruised; boil again for an hour, skimming thoroughly; draw it off, and float some toast covered with yeast in it; leave it to work for two or three days, then pour into a clean cask, and, when all fermentation is over, bung down tightly. If made the end of August or in September, this wine would be ready to tap about Christmas, and should be bottled in January or March.

(6.) Allow three quarts of elderberries, which are quite ripe and carefully picked over, to every gallon of water; boil, skimming well, until the berries break, then strain the liquor, and to every gallon allow three pounds of moist sugar, and to every four gallons add two ounces of bruised ginger, two ounces of cloves, and two ounces allspice; boil for an hour; work with yeast when nearly cold; cask it the third day, and when all working is over, bung down.

(7.) To every gallon of berries allow a gallon of water: steep in a tub for four days, bruising well each day. Squeeze the pulp, and strain off the juice. To every gallon add three pounds of brown sugar, and spices in the same proportion as in the above recipe; tie the spice in a muslin bag; boil all the ingredients for an hour; work with yeast when nearly cold; then pour into a well-cleaned cask, and bung down when the fermenting operation has quite ceased. Bottle off in two or three months. Into every bottle put a lump of white sugar and a little brandy.

(8.) To one gallon of berries add three quarts of water; bruise in a tub, and stand for three days. To every quart of liquor allow one pound of moist sugar, one ounce of ginger, and one ounce of cloves, both bruised (the spice should be put into muslin bags); put all together into a perfectly clean vessel, and boil for one hour; then pour into an earthenware pan; when cool enough to dip in the finger, put in a tablespoonful of brewers' yeast; let it work three days, then skim and put into a small cask just large enough to hold the amount. Keep out the air for three weeks, but do not bung down close until that period has elapsed. Tap in two months to test it; if fine, bottle off.

I have given a variety of recipes for making this wine, as it is a very favorite beverage, more especially in country places. A glass of well-made elderberry wine taken hot at bedtime in the cold weather is by no means to be despised, and a drink I have frequently been called upon to taste in farmhouses about Christmas time. In Cornwall it is quite a custom for farmers' wives to offer any visitor who happens to drop in a slice of what is there termed yellow (meaning saffron) cake and a glass of home-made wine, usually elderberry, and very well made it generally is.

Elder Beer Made with Ginger.—Take a bushel of clean-picked ripe elderberries; put them into a barrel of strong wort; boil up the liquor in a copper for a few minutes, then strain it off, and, when cold, return it to the barrel, and work it in that, not in an open tub; add a pound of whole ginger, and stand for ten months in the barrel, well bunged down, before using it.

Mead is an old-fashioned beverage, but a very pleasant one, if care is taken in making it. It is generally made over-strong, too much honey being used to the proportion of water. The following is a good recipe: (1) On thirty pounds of honey (clarified) pour thirteen gallons of soft water, boiling hot. Clarify with the whites of eggs, well beaten; boil again, remove all scum as it rises, add one ounce of best hops, and boil for ten minutes, then pour the liquor into a tub to cool, spreading a slice of toast on both sides with yeast, and putting it into the tub when the liquor is nearly cold. The tub should stand in a warm room. When fermentation has thoroughly begun, pour the mixture into a cask, and, as it works off, fill up the cask, keeping back some of the liquor for this purpose. Bung down closely when fermentation has ceased, leaving a peg-hole, which can be closed up in a few days. Let it remain a year in the cask before bottling off.

(2) To fifteen pounds of honey add six gallons of water; clarify the honey with white of eggs; boil for ten minutes, and keep thoroughly skimmed; add a handful of mixed herbs, thyme, rosemary tops, and bay leaves; boil for half an hour more; strain the mixture into a tub upon five pints of ground malt; stir well together, and, when lukewarm, strain through a cloth into another tub; work it with yeast, and, when fermentation is set up, pour it into a cask. Suspend in the cask a muslin bag containing sliced ginger, one-half an ounce, one-quarter of an ounce each of cloves, nutmeg, and mace, well bruised; bung up tightly when it has ceased working, letting the bag of spices remain. It should stand in the wood for a year, and then be bottled off.

Sack Mead.—To every gallon of water allow four pounds of honey; boil for three-quarters of an hour, skimming well; to each gallon of liquor add half an ounce of hops; boil again for a quarter of an hour; pour it into a tub, and let stand for twenty-four hours, working with yeast; then pour into the cask, and to thirteen gallons of liquor allow a quart of sack. Close lightly until all fermentation has ceased, then bung up close. If a large cask, allow a year in work before bottling off.

American Mead is made with cider. Take twenty pounds of honey and twelve gallons of good cider, and blend them together in a tub; ferment with yeast, then pour into a cask, and add half a gallon of rum, half a gallon of French brandy, four ounces of red tartar, dissolved, and half an ounce of cloves. Bung down close when it has ceased working, and bottle off at the end of three months; it will be fit for use three months afterward.

A wine called *Saragossa* is made with honey. To every gallon of water used add a handful of fennel root and two sprigs of rue; boil carefully for half an hour, and then strain through a hair sieve; add to each gallon of this liquor three pounds of well-clarified honey; boil for two hours after the addition of the honey, skimming frequently; when the liquor is quite cold, pour it into a clean cask, keeping it for twelve months before bottling off, and six or eight months in bottle before use.

A very useful and economical wine for culinary purposes can be made with honey and cider in the following manner: Take some new cider from the press, and mix it with as much clarified honey as will support an egg; boil it in an enameled saucepan for half an hour, skimming it well all the time; when entirely cool, pour it into a cask, but do not quite fill it; bung down close when all fermentation is over, and keep in the cask six or eight months before bottling off, after which it will be fit to drink in two months. This is a rich, strong wine, keeps well, and answers admirably for cooking purposes instead of white wine.

Balm Wine.—(1) Into eight gallons of water put twenty pounds of moist sugar; boil for two hours, skimming thoroughly; then pour into a tub to cool; place two and a half pounds of balm tops, bruised, into a barrel with a little new yeast; when the liquor is cold, pour it on the balm; stir it well together, and let it stand twenty-four hours, stirring it frequently; then close it up tightly at first, and more securely after fermentation has quite ceased; when it has stood two months, bottle off, putting a lump of sugar into each bottle; cork down well, and keep in bottle at least a year.

(2) Put a peck of balm leaves into an open tub; pour on them four gallons of boiling water; cover up the tub, and let them infuse for twelve or fourteen hours; strain the liquor at the end of that time through a hair sieve, and to every gallon add two pounds of good moist sugar, stirring well for twenty minutes; take the whites of four eggs, whisk them over the fire in a saucepan; remove it from the fire as the scum rises, and skim the latter off; then add it to the liquor; boil the whole for three-quarters of an hour, letting it work three or four days before you tun it; bung down, and, when fine, bottle it off; in six or eight months it will be fit to drink.

The fruit of the bilberry or bleaberry (*Vaccinium myrtillus*), in places where it grows plentifully, is often made into wine. It grows chiefly on moors and in waste places, and is a small shrub about a foot or so in height. In Great Britain it is found mostly in the northern counties and in the hilly districts of the southern counties. Its flowers appear in May, and its fruit ripens in autumn. Two other species of *Vaccinium*, the red (the cranberry) and the black (the whortleberry), are also common in many parts of this country, and are used, as are bilberries, for tarts, preserves, and jellies.

Bilberry Wine.—The fruit should be picked on a very dry day, when it is quite ripe. The leaves and stalks must be carefully removed from the berries and the fruit, then weighed. To four gallons of fruit allow either six gallons of cold water or else three gallons of water and three of cider, and ten pounds of good moist sugar; let all these ingredients ferment in an open tub until working is over; then add half a gallon of brandy, a handful of lavender and rosemary leaves mixed, two ounces of powdered ginger, and two ounces of powdered tartar; let the liquor rest after this addition for forty-eight hours, then strain very carefully through a hair sieve into a perfectly clean cask, laying the bung lightly on the bung-hole until the working is quite over, and no hissing sound is heard; then close down quite tightly, and bottle off at the end of three months; keep six or eight months in bottle before use.

Cranberries can be made into wine in the same way. In America the cranberry is largely cultivated, and forms a considerable article of commerce, a quantity of the fruit being exported. In the northern parts of Russia it is also very abundant.

Ratafia, for flavoring, is by no means difficult to make when the peach is in season. The following is a simple recipe: Blanch two ounces of peach or apricot kernels; bruise them well; put them into a bottle, and fill it nearly up with good brandy; dissolve in a cup of cold water half a pound of white sugar candy, and add it to the brandy after it has stood for a month on the kernels; strain off the kernels before you add the sugar; then filter through paper, and bottle off in small bottles for use. Another rather more expensive method of making it is to take fifty bruised peach kernels, quarter of a pound of bitter almonds, one pound of white sugar candy, and mix thoroughly with one and a half pints of rectified spirits of wine; then add three quarts of water and one and a half gallons of malt spirits.—*Confectioners' Journal.*

HOW TO SHIP APPLES TO EUROPE.

THE demand for American apples in Great Britain has increased of late years to such an extent that for the season beginning August, 1885, and ending May, 1886, the total shipments to the three principal ports, Liverpool, London, and Glasgow, aggregated 862,000 barrels. The magnitude of the business has attracted the attention of many who have no means of ascertaining the requirements for its proper transaction. These facts induce us to believe that instructions as to the proper course to be pursued will be welcome to a large number of people throughout the apple-growing district.

The most important point to be observed is the *packing*. The barrels should be new ones made for the purpose. The filling should be made on a platform of boards, and not on the ground. All *wormy* or *bruised* fruit should be rejected. The size is not a matter of prime importance. The first layer of apples should be very fine, and uniform in size, should be placed in the barrel stems down, as the bottom becomes the head when the barrel is filled; the remainder should be poured in from baskets, care being used not

to bruise any in the operation, and the barrel be well shaken after each basketful until it appears full. More should then be placed on top, projecting at least half the thickness of an apple above the top of the chine of the barrel, the head placed on the apples, and with a *screw press* gently forced into the barrel. The barrels must be well nailed, and lining hoops nailed around both the heads to keep them in place.

The shipping mark must be put on the *head* of the barrel, and it is a matter of no small importance what that mark is. A plain *stencil* is far the best—the plainer, the better; but shippers who send often must remember not to use their *brand* except for the *best* parcels. If they wish to send fruit that is not up to their standard, it is better to vary their mark, as a reputation for good packing is easily established by any shipper, but may be destroyed entirely if the same brand is used on a barrel of inferior fruit. Some brands of fruit hardly need to be shown at the sales, so well has their reputation become established.

All exported apples are sold at auction immediately after landing. The delivery must, by a rule of the trade, be made within twenty-four hours.

Almost any good keeper will do to go over. Apples of the frail nature of Astrachans will not stand the voyage, but the list of those that *will* do is a long one. Baldwins, Seeks, Pomeroys, Jonathans, Russets, Kings, Phenix, Spitzenburgs, Swaars, Greenings, Spies, Gravensteins, and Newtown Pippins all do well. Some shippers send *all* kinds, and think that is the best plan; the trip across is now made in such a short time that apples keep very well if they are sound when shipped and not over-ripe.

Finally, a shipper in the interior wishing to export his apples has nothing to do except to follow the preceding directions and put his apples on board the most convenient transportation line, consigned to some exporter. He has then only to wait twelve to fifteen days, when he will receive a check for the amount of the net proceeds; and when good fruit has been shipped, the results are usually satisfactory. It is as easy to ship to Europe as to New York.—*N. E. Farmer.*

PHYSICAL EXERCISE.*

By CARL H. HORSCH, M.D., Dover, N. H.

A WELL regulated use of our voluntary muscles is a very important aid for the function of digestion and

FIG. 1.—EXERCISE FOR THE ABDUCTOR MUSCLES.

assimilation of the food, circulation and mixing of the blood, growth, production and reproduction of our system.

The circulation in the veins, wherein the blood is carried from the parts of the body back to the heart, is influenced to a great extent by the contraction of the muscle fibers. If the fibers of our muscles contract, a pressure against the surrounding vessels takes place and the blood is pushed toward the heart. The valves which we find in the veins prevent the blood from flowing

FIG. 2.—EXERCISE FOR THE ABDUCTOR MUSCLES.

back again when the contraction ceases, a next contraction brings the blood still nearer and at a certain time back to the heart. Gaskell and others have demonstrated by experiments that the flow of blood through the muscles is increased during the period of contraction. For that part of the circulation of the blood, systematic free exercises are the most effectual, and in order to carry them out systematically we must know what different motions the muscles produce.

If we commence with the here illustrated motions, we are sure that we have brought the voluntary muscles, which can be entirely controlled by our will, into rational, systematic physiological action, and have them better prepared for daily labor, forced muscular exercises, as gymnastics, boating, etc., for a better balance of our body, and for a development of agility and vigor. The following illustrated exercises should be made at least three times a day, and every motion three times, which can be executed in about two minutes. There are many vocations where persons use or even overtax some of their voluntary muscles, but do not contract

FIG. 3.—EXERCISE FOR THE ATTRACTION MUSCLES.

FIG. 4.—EXERCISE FOR THE RETRACTION MUSCLES.

the fibers of the other sets of muscles, which the circulation of the blood and other physiological functions require.

1. The abductor muscles by spreading the extremities, and move them from the middle line of the body.

2. The abductor muscles are well used by drawing the limbs as close as possible to the middle line of the body; you can do it after each abduction, but it is better to draw the limbs close to the body by separate motions, and when the extremities are about one inch from the body.

3. Attraction muscles are used by making a step

FIG. 5.—EXERCISE FOR THE EXTENSOR MUSCLES.

forward, and with every step throwing the arms forward.

4. Retraction muscles by stepping backward, and with every step throwing the arms backward.

5. Use the extensor muscles by stretching the body, the right arm and leg, then the left arm and leg.

6. The flexor muscles by bending the body, neck, right arm and leg, then left arm and leg.

7. Rotator muscles by throwing the head as much as possible to the right and then to the left, and turn the arms and then the legs on their axes.

8. The actions of the pronator and supinator muscles are illustrated on one figure; you find the right hand pronated and the left supinated, first exercise hand and wrist, then feet and ankles.

9. Depressor muscles, which draw the lower lip, the angle of the mouth, and the side of the nose down.

To stretch and bend our arms and legs would not be a sufficient physical exercise for a normal circulation in these extremities, because the rotator muscles, pronators, and the supinators must also be brought into action for that purpose.

FIG. 6.—EXERCISE FOR THE FLEXOR MUSCLES.

Breathing is accelerated by proper exercise of the voluntary muscles, and, therefore, we have a more appropriate exchange of oxygen, carbonic acid, and water.

The heart beats more frequently and forcibly during moderately energetic, regulated exercise, and the blood and its nourishing constituents are better distributed.

FIG. 7.—EXERCISE FOR THE ROTATOR MUSCLES.

The digestion and the appetite are improved by physical exercise, on account of the increased waste, more rapid absorption, and greater demand of food; but as there is an increased flow of blood to the stomach during digestion, in order to supply more gastric juice, exercise right after a meal interferes with that process.

Systematic exercise gives also tone to the nervous system. Outdoor exercise gives us better air, more light, and a different pressure of the atmosphere than our buildings contain. Out of town exercise is beneficial, as we breathe no impurities which are floating in the air in thickly settled places.

FIGS. 8 AND 9.—EXERCISE FOR THE PRONATOR AND SUPINATOR MUSCLES.

Swedish gymnastics, or so-called "movement cure," is an effort to produce more active contraction of the voluntary muscles and improve the nutrition of the same. Every school ought to have a properly arranged place and apparatus for gymnastics and for free exercises of all the voluntary muscles. Then the teachers and scholars can improve their physical condition, and

* Reprinted by permission from the Fifth Annual Report of the New Hampshire State Board of Health, 1886.—*Sanitary News.*

have systematic means by which the body will be developed to better usefulness and symmetry.

The present "rough and tumble sports" are more likely to be injurious. Erasmus Wilson says: "In mind lies the great secret of beneficial exercise, and without it, exercise is a misnomer and a fraud on the constitution." When mental culture and physical education are going hand in hand, various crippled conditions of disease may be prevented, and a more vigorous people will exist.

There are already a number of educational institutions where physical education is taught, and also gymnastic institutions, athletic clubs—the German *Turnverein* and the American *Turnerbund*.

THE SOLAR SYSTEM.*

THE solar system, so named from *sol* (Latin), the sun, consists of the sun in the center, numerous planets, and an unknown number of bodies named comets. The word planet is from the Greek *planao*, to wander, because the few such bodies known to the ancients were chiefly remarkable in their eyes on account of their constantly shifting their places with reference to the other luminaries of the sky. Comets are so named from *coma* (Latin), a head of hair, because they seem to consist of a bright spot, with a long brush streaming behind.

Some of the planets have other planets moving around them as centers—the moon, for instance, round the earth. These are called secondary planets, moons, or satellites; while those that move round the sun are called primary planets. The primary planets consist—1st, of eight larger planets, including the earth; their names, in the order of their nearness to the sun, are Mercury, Venus, the earth, Mars, Jupiter, Saturn, Herschel or Uranus, and Neptune. 2d. A group of small planets or planetoids, also called asteroids, considerable in number.

The planets move round the sun on nearly one level or plane, corresponding with the center of his body, and in one direction, from west to east. The secondary planets, in like manner, move in planes round the centers of their primaries, and in the same direction, from west to east. These are denominated revolutionary motions; and it is to be observed that they are double in the case of the satellites, which have at once a revolution round the primary, and a revolution, in company with the primary, round the sun. The path described by a planet in its revolution is called its orbit.

Each planet, secondary as well as primary, and the sun also, has a motion in its own body like that of a bobbin upon a spindle. An imaginary line, forming, as it were, the spindle of the sun or planet, is denominated the axis, and the two extremities of the axis are called the poles. The axes of the sun and planets are nearly all at a right angle with the plane of the revolutionary movements. The motion on the axis is called the rotary motion, from *rota*, the Latin for a wheel. The sun, the primary planets, and the satellites, with the doubtful exception of two attending on Uranus, move on their axes in the same direction as the revolutionary movements, from west to east.

The sun is a sphere of 882,000 miles in diameter, or 1,384,472 times the bulk of the earth, moving round its axis in 25 days. When viewed through a telescope, the surface appears intensely bright and luminous, as if giving out both light and heat to the surrounding planets. But on this surface there occasionally appear dark spots, generally surrounded with a border of less dark appearance; some of which spots have been calculated to be no less than 45,000 miles in breadth, or nearly twice as much as the circumference of the earth. The region of the sun's body on which the spots appear is confined to a broad zone engirdling his center. They are sometimes observed to come into sight at his western limb, to pass across his body in the course of twelve or thirteen days, and then disappear like something melted and absorbed into a burning fluid. Upon the bright parts of the sun's body there are also sometimes observed streaks of unusual brightness, as if produced by the ridges of an agitated and luminous fluid. It has been surmised that the sun is a dark body, enveloped in an atmosphere calculated for giving out heat and light, and that the spots are produced by slight breaks or openings in that atmosphere, showing the dark mass within. Though so much larger than the earth, the matter of the sun is only about a third of the density or compactness of that of our planet, or a little more than the density of water.

The sun is surrounded to a great distance by a faint light, or luminous matter of extreme thinness, shaped like a lens or magnifying glass, the body of the sun being in the center, and the luminous matter extending in the plane of the planetary revolutions, till it terminates in a point. At particular seasons, and in favorable states of atmosphere, it may be observed before sunrise, or after sunset, in the form of a cone pointing obliquely, above the place where the sun is either about to appear or which he has just left. It is termed the zodiacal light.

Mercury, the nearest planet to the sun, is a globe of about 2,950 miles in diameter, rotating on its axis in 24 hours and 5½ minutes, and revolving round the central luminary, at a distance of 37,000,000 of miles, in 88 days. From the earth it can only be seen occasionally in the morning or evening, as it never rises before, or sets after, the sun at a greater distance of time than 1 hour and 50 minutes. It appears to the naked eye as a small and brilliant star, but when observed through a telescope is horned like the moon, because we only see a part of the surface which the sun is illuminating. Mountains of great height have been observed on the surface of this planet, particularly on its lower or southern hemisphere. One has been calculated at 10¼ miles in height, being about eight times higher, in proportion to the bulk of the planet, than the loftiest mountains upon the earth. The matter of Mercury is of much greater density than that of the earth, equaling lead in weight; so that a human being placed upon its surface would be so strongly drawn toward the ground as scarcely to be able to crawl.

Venus is a globe of about 7,800 miles in diameter, or nearly the size of the earth, rotating on its axis in 23 hours, 21 minutes, and 19 seconds, and revolving round the sun, at the distance of 68,000,000 of miles, in 225 days. Like Mercury, it is visible to an observer on the earth only in the morning and evening, but for a greater space of time before sunrise and after sunset. It appears to us the most brilliant and beautiful of all the planetary and stellar bodies, occasionally giving so much light as to produce a sensible shadow. Observed through a telescope, it appears horned, on account of our seeing only a part of its luminous surface. The illuminated part of Venus occasionally presents slight spots. It has been ascertained that its surface is very unequal, the greatest mountains being in the southern hemisphere, as in the case of both Mercury and the earth. The higher mountains in Venus range between 10 and 22 miles in altitude. The planet is also enveloped in an atmosphere like that by which animal and vegetable life is supported on earth, and it has consequently a twilight. Venus performs its revolution round the sun in 225 days. Mercury and Venus have been termed the inferior planets, as being placed within the orbit of the earth.

The earth, the third planet in order, and one of the smaller size, though not the smallest, is important to us as the theater on which our race have been placed to "live, move, and have their being." It is 7,902 miles in mean diameter, rotating on its axis in 24 hours, at a mean distance of 95,000,000 of miles from the sun, round which it revolves in 365 days, 6 hours, and 9 minutes. As a planet viewed from another of the planets, suppose the moon, "it would present a pretty, variegated, and sometimes a mottled appearance. The distinction between its seas, oceans, continents, and islands would be clearly marked; they would appear like brighter and darker spots upon its disk. The continents would appear bright, and the ocean of a darker hue, because water absorbs the greater part of the solar light that falls upon it. The level plains (excepting, perhaps, such regions as the Arabian deserts of sand) would appear of a somewhat darker color than the more elevated and mountainous regions, as we find to be the case on the surface of the moon. The islands would appear like small bright specks on the darker surface of the ocean; and the lakes and Mediterranean Sea like darker spots and broad streaks intersecting the bright parts, or the land. By its revolution round the axis, successive portions of the surface would be brought into view, and present a different aspect from the parts which preceded."

The form of the earth, and probably that of every other planet, is not strictly spherical, but spheroidal; that is, flattened a little at the poles or extremities of the axis. The diameter of the earth at the axis is 26 miles less than in the cross direction. This peculiarity of the form is in consequence of the rotary motion, as will be hereafter explained.

The earth is attended by one satellite, the moon, which is a globe of 2,160 miles in diameter, and consequently about a 49th part of the bulk of the earth, revolving round its primary in 27 days, 7 hours, 43 minutes, and 11 seconds, at the distance of 240,000 miles. The moon is 400 times nearer the earth than the sun is; but, its diameter being at the same time 400 times less than that of the sun, it appears to us of about the same size. The moon rotates on her axis in exactly the same time as she revolves round the earth. Inspected through a telescope, her surface appears of unequal brightness and extremely rugged. The dark parts, however, are not seas, as has been supposed, but more like the beds of seas or great alluvial plains. No appearance of water, or of clouds, or of an atmosphere, has been detected. The surface presents numerous mountains, some of them about a mile and three-quarters in height, as has been ascertained by measurement of the shadows which they cast on the neighboring surface. The tops of the mountains of the moon are generally shaped like a cup or basin, with a small eminence rising from the center, like many volcanic hills on the earth. It has hence been surmised that the moon is in a volcanic state, as the earth appears to have been for ages before the creation of man, and that it is perhaps undergoing processes calculated to make it a fit scene for animal and vegetable life.

The moon, turning on its axis once in a little more than 27 days, presents every part of its surface in succession to the sun in that time, as the earth does in 24 hours. The day of the moon is consequently nearly a fortnight long, and its nights of the same duration. The light of the sun, falling upon the moon, is partly absorbed into its body; but a small portion is reflected or thrown back, and becomes what we call moonlight. The illuminated part from which we derive moonlight is at all times increasing or diminishing in our eyes, as the moon proceeds in her revolution round our globe. When the moon is at the greatest distance from the sun, we, being between the two, see the whole of the illuminated surface, which we accordingly term full moon. As the moon advances in her course, the luminous side is gradually averted from us, and the moon is said to wane. At length, when the satellite has got between the earth and sun, the luminous side is entirely lost sight of. The moon is then said to change. Proceeding in her revolution, she soon turns a bright edge toward us, which we call the new moon. This gradually increases in breadth, till a moiety of the circle is quite filled up; it is then said to be half moon. The luminary when on the increase from new to half is termed a crescent, from *crescens*, Latin for increasing; and this word has been applied to other objects of the same shape—for instance, to a curved line of buildings.

In the early days of the new moon, we usually see the dark part of the body faintly illuminated, an appearance termed the old moon in the new moon's arms. This faint illumination is produced by the reflection of the sun's light from the earth, or what the inhabitants of the moon, if there were any, might be supposed to consider as moonlight. The earth, which occupies one invariable place in the sky of the moon, with a surface thirteen times larger than the apparent size of the moon in our eyes, is then at the full, shining with great luster on the sunless side of its satellite, and receiving back a small portion of its own reflected light. The light, then, which makes the dark part of the moon visible to us may be said to perform three journeys, first from the sun to the earth, then from the earth to the moon, and finally from the moon back to the earth, before our eyes are enabled to perceive this object.

Mars, the fourth of the primary planets, is a globe of 4,189 miles in diameter, or little more than a half of that of the earth; consequently, the bulk of this planet is only about a fifth of that of our globe. It performs its rotation on its axis in 24 hours, 39 minutes, and 13⅔ seconds, and revolves round the sun, at a distance of 142,000,000 of miles, in 686 days, 22 hours, and 18 seconds. Mars appears to the naked eye of a red color; from which circumstance it was, probably, that the ancients bestowed upon it the name of the god of war. Inspected through a telescope, it is found to be occasionally marked by large spots and dull streaks, of various forms, and by an unusual brightness of the poles. As the bright polar parts project from the circular outline of the planet, it has been conjectured that these are masses of snow, similar to those which beset the poles of the earth.

Vesta, Ceres, Pallas, and Juno are among the globes, revolving between the orbits of Mars and Jupiter, in paths near and crossing each other, and which are not only much more elliptical than the paths of the other planets, but also rise and sink much further from the plane of the general planetary revolutions.

Jupiter is the largest of all the planets. Its diameter is nearly eleven times that of the earth, or 89,170 miles, and its volume or mass is consequently 1,281 times that of our globe. The density of Jupiter is only a fourth of that of the earth, or about the lightness of water; and a human being, if transferred to it, would be able to leap with ease over a pretty large house. It performs a rotation on its axis in 9 hours, 55 minutes, and 33 seconds, or about two-fifths of our day. It revolves round the sun, at a distance of 490,000,000 of miles, in 4,330 days, 14 hours, and 39 minutes, or nearly twelve of our years. Viewed through a telescope, Jupiter appears surrounded by dark lines, or belts, which occasionally shift, melt into each other, or separate, but sometimes are observed with little variation for several months. These belts are generally near the equator of the planet, and of a broad and straight form; but they have been observed over his whole surface, and of a lighter, narrower, and more streaky and wavy appearance. It is supposed that the dark parts are lines of the body of the planet, seen through openings in a bright, cloudy atmosphere.

Jupiter is attended by four satellites, which revolve round it, in the same manner as the moon round our globe, keeping, like it, one face invariably presented to their primary. They are of about the same size, a little larger in diameter than our moon; the first having a diameter of 2,508, the second of 2,068, the third of 3,377, and the fourth of 2,890 miles.

Saturn, seen through a telescope, is the most remarkable of all the planets, being surrounded by a ring, and attended by seven satellites. In bulk this is the second of the planets, being 79,042 miles in diameter, or about 995 times the volume of the earth. Its surface appears slightly marked by belts like those of Jupiter. It performs a rotation on its axis in 10 hours and 16 minutes, and revolves round the sun, at a distance of 900,000,000 of miles, in 10,746 days, 19 hours, and 16 minutes, or about 29½ of our years. At such a distance from the sun, that luminary must be diminished to one-eightieth of the size he bears in our eyes, and the heat and light in the same proportion. The matter of Saturn is one-eighth of the density of our earth.

The ring of Saturn surrounds the body of the planet in the plane of its equator. It is thin, like the rim of a spinning-wheel, and is always seen with its edge presented more or less directly toward us. It is luminous with the sun's light, and casts a shadow on the surface of the planet, the shadow of which is also sometimes seen falling on part of the ring. The distance of the inner edge from the planet is calculated at about 19,000 miles; its entire breadth from the inner to the outer edge is 28,538; the thickness is not more than 100. In certain positions of the planet we can see its surface at a considerable angle, and the openings or loops which it forms on the sides of the planet. At other times we see its dark side, or only its edge. From observations made upon it under favorable circumstances, it is found to be apparently divided near the outer edge by a dark line of nearly 1,800 miles in breadth, as if it were divided into two concentric rings. From other appearances, it has been surmised to have other divisions, or to have a collection of several concentric rings. It is also occasionally marked by small spots. The ring of Saturn rotates on its own plane in 10 hours, 32 minutes, and 15 seconds, being about the same time with the rotation of the planet.

The seven satellites of Saturn revolve round it, on the exterior of the ring, and almost all of them in nearly the same plane. They are so small as not to be visible without a powerful telescope.

Uranus, or Herschel, is a globe of 35,112 miles in diameter, rotating on its axis in 7 hours, and performing a revolution round the sun, at a distance of 1,800,000,000 of miles, in 84 of our years. The sun to this remote planet must appear only a 400th part of the size which he bears in our eyes.

Neptune is the most remote planet of the solar system, and the third in size. It is invisible to the naked eye. Its revolution round the sun is performed in about 165 of our years, and at a distance of 2,746,000,000 of miles from the sun. Its diameter is 36,620 miles. Nothing is known of the period of rotation or of the atmospheric conditions of this planet.

Some idea may be obtained of the comparative size of the principal objects of the solar system by supposing a globe of two feet diameter, placed in the center of a level plain, to represent the sun; a grain of mustard seed, placed on the circumference of a circle 164 feet in diameter, for Mercury; a pea on a circle of 284 feet for Venus; another pea, on a circle of 430 feet, for the earth; a large pin's head, on a circle of 654 feet, for Mars; four minute grains of sand, in circles of from 1,000 to 1,200 feet, for Vesta, Ceres, Pallas, and Juno; a moderate sized orange on a circle of nearly half a mile in diameter, for Jupiter; a small orange, on a circle of four-fifths of a mile in diameter, for Saturn; a small plum or full-sized cherry, on a circle a mile and a half in diameter, for Uranus; and a good-sized plum in a circle about two miles and a half in diameter, for Neptune. It is calculated that the united mass of the whole of the planets is not above a 600th part of the mass of the sun.

COMETS.

Comets are light, vapory bodies, which move round the sun in orbits much less circular than those of the planets. Their orbits, in other words, are very long

* From "Collier's Cyclopedia of Social and Commercial Information." Published by P. F. Collier, New York.

ellipses, or ovals, having the sun near one end. Comets usually have two parts, a body or nucleus, and a tail; but some have a body only. The body appears as a thin, vapory, luminous mass, of globular form. It is so thin that, in some cases, the stars have been seen through it. The tail is a lighter or thinner luminous vapor surrounding the body, and streaming far out from it, in one direction. A vacant space has been observed between the enveloping matter of the tail and the body; and it is equally remarkable that the tail has in some instances appeared less bright along the middle, immediately behind the nucleus, as if it were a stream which that and the nucleus had in some measure parted in two.

Out of the great multitude—certainly not less than 1,000—which are supposed to exist, about 150 have been made the subject of scientific observation. Instead of revolving, like the planets, nearly on the plane of the sun's equator, it is found that they approach his body from all parts of surrounding space. At first, they are seen slowly advancing, with a comparatively faint appearance. As they approach the sun, the motion becomes quicker, and at length they pass round him with very great rapidity, and at a comparatively small distance from his body. The comet of 1680 approached within one-sixtieth of his diameter. After passing, they are seen to emerge from his rays, with an immense increase to their former brilliancy and to the length of their tails. Their motion then becomes gradually slower, and their brilliancy diminishes, and at length they are lost in distance. It has been ascertained that their movement round the sun is in accordance with the same law which regulates the planetary movements, being always the quicker the nearer to his body, and the slower the more distant. In the remote parts of space their motions must be extremely slow.

Comets often pass unobserved, in consequence of the part of the heavens in which they moved being then under daylight. During a total eclipse of the sun which happened sixty years before Christ, a large comet, not formerly seen, became visible near the body of the obscured luminary. On many occasions, their smallness and distance render them visible only by the aid of the telescope. On other occasions, they are of vast size. The comet now called Halley's, at its appearance in 1456 covered a sixth part of the visible heavens, and was likened to a Turkish cimeter. That of 1680, which was observed by Sir Isaac Newton, had a tail calculated to be 123,000,000 of miles in length, a space greater than the distance of the earth from the sun. There was a comet in 1744 which had six tails, spread out like a fan across a large space in the heavens. The tails of comets usually stretch in the direction opposite to the sun, both in advancing and retiring, and with a slight wave at the outer extremity, as if that part experienced some resistance.

CAUSE OF EARTHQUAKES.

AT the last meeting of the California Academy of Sciences, Prof. Joseph Le Conte, at the request of Prof. Davidson, the president, delivered a lecture on "The general cause of earthquakes, with special reference to the recent ones at Charleston." The lecturer spoke without notes and gave a very interesting discourse to a large audience. He spoke substantially as follows: There is no subject which has more interest than the subject of earthquakes, and the cause is obvious. It is because the origin of earthquakes is hidden from direct observation. Really the phenomena of the earthquake is complex, and that which has most tended to retard investigation is the suddenness with which they occur, creating terror and surprise.

THE SEISMOGRAPH.

This difficulty will soon be gotten over by the use of the seismograph, which will not admit of surprise or other emotion. These instruments are being introduced into all earthquake countries, and principally in Japan, where the most satisfactory observations have been made. There will soon be one at Mount Hamilton, and another at Fulton, and we shall then have a better opportunity of comparing notes with observations made in other places. We shall have a better opportunity to notice the principle of induction. A feature of earthquakes appears to be, that in proportion as we extend our observations of them, they become more common. In Japan there are about 700 a year, or two a day. There is not an hour in any day in the year that the earth is not shaking somewhere. What we want is some theory that will give significance and coherence to the phenomena.

IMMEDIATE AND REMOTE CAUSE.

There are two kinds of causes. One is the immediate cause of the observed phenomena; the other is the remote, ultimate, *real* cause, hidden deep in the bowels of the earth. As to the immediate cause, this we know: It is a rising of the surface of the earth from some hidden force, and spreading on the surface of the earth in a series of elastic earth waves. These are similar somewhat in origin to sound waves. The difference in sound waves and earth waves is a difference merely of rapidity of vibration. If they are so rapid that they are not noticed by the nerves, they are sound waves. If heavy, they become more or less dangerous, and we call them earthquakes. The phenomena are similar. The smaller ones we notice as sound; the heavier ones are from earthquakes. Suppose a concussion, no matter from what cause—say several tons of nitro-glycerine, buried deep in the earth. (Here the lecturer showed a diagram to represent a portion of the earth's crust, 40 miles long, 20 miles broad, and 10 miles deep, the focal point being in the lower center of the figure, and the effect shown by concentric waves similar to that produced on the surface of the water when a stone or other substance is thrown in.) These concentric waves move with great rapidity, and it is the passage of these waves that constitutes what we call an earthquake. We must keep in our minds the direction of the wave motion and the direction of their propagation. Another thing we must notice is the velocity of the earth's motion and the velocity with which the wave is transmitted. The latter is by far greater than the former. By means of the seismograph we shall be able to accurately record these motions, and not only that, but the day, hour, minute, and second at which they occur. The pencil, as soon as the earthquake is felt, will mark the time, the duration, and the rapidity with which it is traveling, and even the motion of the wave will be recorded. There are several pencils doing duty, and these will also tell the direction of the wave and its angle of emergence, by which means the probable point of focus can be arrived at.

Several cases have proved that the focal point can be fixed. In the earthquake of 1834 the subject was discussed largely, and it was thought that the starting point of the shake was 50 to 100 miles in the interior of the earth. It was nothing of the kind, being only about nine miles. The one in Italy started from a depth of six miles. One in Japan was only three miles. One great earthquake recorded was found to have its focal center only half a mile in depth. This was, in consequence, of exceedingly limited character. It has been shown in many cases that the focus was not a point, but a fissure eight, nine, or ten miles in length. This is a most important discovery. As to immediate causes of earthquakes, they are the result of a series of elastic shakes, and, like all waves, subject to refraction, interference, etc.

The more remote the cause of the concussions, the more remote the true cause of the earthquake. The agencies of the earthquake are of two kinds—the igneous and the aqueous. The one rough-hews the features of the earth, and the other shapes those features. One makes the great sea-bottoms and mountain chains, and the other makes the beautiful scenery and details of form of the earth. The earth forces we know about; the other is from the sun.

EARTHQUAKES AND VOLCANOES.

The association of earthquakes with volcanoes is natural. Take any map and you will note the similarity between the earthquake and the volcanic countries, although sometimes there is no connection. They never have volcanic eruptions in the Hawaiian Islands without earth shocks. There are also, of course, earthquakes without volcanic eruptions. But when volcanic activity ceases, we are apt to have earthquakes. After Stromboli stopped its eruptions, earthquakes were frequent. On the contrary, where they have had shocks for years the sudden opening of a volcano seemed to stop them. Some people think that there are cavities in the earth filled with steam, which finally discharge one into the other, causing earthquakes. In my opinion the fracture is more apt to produce them than the escaping steam. It is a curious fact that the Italian and French hold to gas being the probable cause, while the Americans, German, and English hold different views. In 1835 there was an earthquake on the coast of South America, after which the entire coast line was elevated from ten to twelve feet. There had evidently been a fracture and a slip, or likely a readjustment of an old slip. It is a well known fact that the interior of the earth is shrinking faster than the shell, and something must give way, and it does give way by the crashing of the shell. Now, perhaps, an earthquake is produced by the snapping or readjustment of old fractures—a readjustment of broken parts. In South America changes are constantly going on. If the earth yields gradually to the forces which are constantly raising the coast of South America, there will be no earthquakes; but if it resists, the force will eventually oblige it to yield suddenly, and an earthquake is the result.

Again, it is well known that the interior of the earth is contracting more rapidly than the surface, and the shrinkage of the shell on this is apt to cause motion of the surface; it gives way by crushing or folding. Every time the crust thus moves, we have an earthquake. Suppose the earth is composed of great crust-blocks, each hundreds of miles in extent. As the interior shrinks, those blocks must settle. If you look at the Coast Range of mountains, you will see there are at least five bends one way and five another, and if those were spread out, it would be found that two miles had been mashed into one. In one place 16 miles spread out would make 96 miles. This is not extreme. It is the Appalachian chain. In the highlands of Scotland there are immense masses folded over each other. These forces are almost inconceivable. It did not take place slowly. The whole surface of continents is broken by fissures, some 200 or 300 miles long. This breaks it up into great blocks, which slip and slip.

I know no better illustration than the

GREAT PLATEAU OF THE COLORADO.

That region is traversed by north and south fissures, 200 to 300 miles long, separated 20 or 30 miles, thus making great, oblong blocks of earth—sometimes very high. Some of the slips are 5,000 or 10,000 feet and the escarpments 2,000 feet. In the Basin region there are great earth blocks tilted on edge. These great escarpments did not occur at once, but every paroxysm caused an earthquake. This is by far the most frequent cause of earthquakes.

THE ELECTRIC THEORY.

The most popular theory concerning earthquakes is that electricity causes them. I do not care to go into this, because it does not deserve more than a passing notice. Still, some scientists of repute uphold this theory. I will not assert there is "nothing in it," but only because the true scientist is not disposed to be bigoted. But this I can say: I never heard or read the slightest scientific proof of this theory. Electricity has taken hold of the popular imagination, so that any inexplicable thing is explained by "electricity." For example, vital force, nerve force, etc., are inexplicable, so many lay it to electrical force. So also with earthquakes—electricity is made the scapegoat. They have said we have earthquakes in California on account of the "glorious climate" and the absence of thunder storms. Others have said our last great earthquakes were before the railroads came in 1869; we have none now. As to

CALIFORNIA EARTHQUAKES,

fissures and slips of crust may occur anywhere. But there are certain places where there are lines of weakness. One of these places is at the line of the foot of a chain of mountains on *one* side, where the bending of the uplifted earth is great. Another place is along the line of continents. Along the base of mountains, say the Sierra Nevada, there is a chance for frequent shocks. The great Inyo earthquake occurred at such a place. There is a split right at the base of the mountain, going for 40 miles with a drop of 20 feet. The Sierra Nevada, in rising, dragged up the more level land gradually with it; but a final readjustment caused an earthquake, as it always will.

The cliffs at the Wasatch Mountains are of similar formation, and some day Salt Lake may be destroyed. On this side of the Coast Range, near Niles and Haywards, there is a line which adjusts itself from time to time, as the foldings of the mountains show. On the Atlantic coast there is a line of weakness extending from New York to the Gulf, the formation being of Tertiary origin, and the consequence is frequent oscillation. When I heard of the Charleston disaster I made up my mind that it was an off-shore line. Earthquakes all over the globe have had points of resemblance to this one. It is usually a movement of the sea bed off shore that gives rise to the sea wave and earthquake. Along the old primordial continent margin is a place where there is a bend in the earth, that makes the ocean bed, and a readjustment of the old contracted margin makes earthquakes possible. Sometimes waves occur, and sometimes not. The old Archaen rocks are covered by Tertiary and other rocks. These rocks broke and slipped and affected less and less the sea-bottom. My object in speaking to you to-night is to put your minds in a position to judge for yourselves when the details of facts of the late earthquakes are available.

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